Ventilation Need:

Roman Times 23-79AD, Pliny wrote of "blackdamp" an excess of nitrogen and carbon dioxide

- *In deep wells the occurrence of sulpurata and aluminosa vapours is fatal to diggers.*
  - *... the air itself becomes noxious with depth, which can be remedied by constantly shaking linen cloths, thus setting the air in motion.*

Ventilation Need:

- 16th Century, Agricola’s De Re Metalica describes state of the art mine ventilation systems using natural & mechanical means to dispel demons - windcatchers and rudimentary fans run by hand, treadmill, wind, water to control blackdamp.
- Around this time ‘Firedamp’ an excess of methane was recognized and in 1621 there was the first recorded fatality from an ignition.

Ventilation Need:

- Supply air (oxygen) so workers can breathe and combustion process of diesel equipment.
- Remove and dilute dust and gases to safe levels.
- Provide thermal comfort for workers and machinery.
- Maintain visibility so mechanized equipment can be operated safely.
- Provide a safe environment to handle mine emergencies such as fires.
- Clear blast fumes before re-entry.
- Cost effective without endangering employees

Oxygen:

- 21% Breathing easiest (normal air conc.).
- 17% Breathing faster & deeper.
- 15% Dizziness, buzzing noise, rapid pulse, headaches, blurred vision.
- 9% May faint or become unconscious.
- 6% Movement convulsive, breathing & heart stops.
- 7% Limit of diesel operation.

- Mine air should not contain less than 19% oxygen.
- No serious effect from overexposure.

- Oxygen depletion from water absorption, oxidization.
- Breathing, heating/combustion, displacement.

Dusts:

- Respirable dust typically 0.5-5 microns i.e. 5/1000mm (visible dust > 25 microns).
- Legally recognized 1912 in S. Africa.
- Silica (quartz) - silicosis of lungs.
- Coal dust - pneumoconiosis of lungs.
- Asbestos fibres - cancer.
- Diesel soot - suspected carcinogen.
- Added risks absorbed chemicals, radio-active attachments.
- Coarse dust >10 microns can affect visibility & cause impaction discomfort.
- Salt, potash & gypsum - nuisance dusts.

Dusts:

- Sources: blasting, drilling, mucking, dumping, loading, transfer points, conveyor drums, crushing.

- Limits TLVs by mass/air volume.

- Controls: collection at source, water suppression,filtration, isolation, dilution with air

Carbon dioxide, CO_2:

- Inert gas normally occurs in air.
- 0.08% breathing easiest (normal concentration).
- 2% respiration increases by 50%.
- 3% respiration increases by 100%.
- 5% respiration increases by 300% & labourous.
- 10% can only be endured for a few minutes.
- Concentrations over 5% reduce oxygen content.
- Typical TLV, 0.5% (5000ppm) CO_2/8hrs.
- Heavier than air can settle in abandoned areas.
- Sources: oxidation organic, rotting timber, heating/ combustion burning wood, diesel engines, blasting, respiration.

Carbon monoxide, CO:

- Toxic, flammable & explosive gas.
- Replaces oxygen on haemoglobin (300:1 affinity).
- 0.04-0.05% no appreciable effect within 1hr.
- 0.06-0.07% noticeable effects within 1hr: headache, dizziness, nausea
- 0.10-0.12% unpleasant, probably not dangerous within 1hr.
- 0.15-0.20% dangerous exposure for 1hr.
- >0.40% death in under 1hr.
- Typical TLV, 0.0035% (35ppm) CO/8hrs.
- Explosive range 12.5-74%.
- Sources: incomplete combustion organics, diesel engines, blasting, mine fires

Oxides of nitrogen, NO & NO_2:

- Corrosive gas forms acid with water vapour.
- 0.004% may be detected by smell.
- 0.006% causes immediate throat irritation.
- 0.010% causes coughing.
- 0.010-0.015% dangerous even for short exposures.
- 0.020-0.070% rapidly fatal with short exposures.
- Typical TLV, 0.0025% (25ppm) NO/8hrs.
- Typical TLV, 0.0003% (3ppm) NO_2/8hrs.
- Sources: diesel engines, blasting

Sulphur dioxide, SO_2:

- Toxic & pungent gas
- 0.0001% acidic taste
- 0.0003% detectable by odour
- 0.0020% irritates eyes & resp. system
- 0.0050% severe burning throat, nose, eyes
- 0.0400% immediately dangerous to life
- Typical TLV, 0.0002% (2ppm) SO_2/8hrs
- Sources: diesel engines, oxidization and blasting of sulphide ores, sulphide dust explosions.

Hydrogen sulphide, H_2S:

- Very toxic & pungent gas (rotten eggs)
- 0.00001-0.0001% detectable by smell
- 0.0005% beginning of toxicity
- 0.005-0.010% irritates eyes & resp. system, loss of smell
- 0.020% subacute poisoning intensified inflammation
- 0.050% acute poisoning serious inflammation
- 0.060% chest pains (corrosion) possibly fatal
- Typical TLV, 0.001% (10ppm) H_2S/8hrs
- Heavier than air may stagnate
- Sources: acidic reaction/heating sulphide ores, bacterial/chemical decomposition of organic, sulphide dust explosions

Other gases etc:

- Methane, explosive - dangerous due to layering potential, strata gas.
- Radon/thoron & daughters, cancer - not only uranium mines, strata gas/dust attachment.
- Hydrogen, highly explosive - battery charging
- Ammonia, corrosive - blasting
- Arsine, toxic & explosive, - backfill, arsenic ores
- Hydrogen cyanide, asphyxiant - backfill from cyanide mill circuits
- Aldehydes & PAHs - diesel engines
- Welding fumes, oil mists, solvents, stench gas

Design criteria - gases:

- In most mines - the first design criteria is typically the dilution of gases.
- Those of primary interest being either:
  - strata gases, such as methane or radioactive
    - *these need individual consideration and methods detailing the specific ventilation requirements of such mines can be found in the recommended literature.*
  - or from the mining process, through diesel powered equipment based extraction and the use of explosives.
    - *these have led to the formation of "Rule-of-thumb" design criteria.*

Rough Planning "Rules":

- 3.0-3.5 m^3/s /kilotonne/month broken rock (ore & waste) in tabular ore bodies or scattered stoping.
- >0.1 m^3/s /kW(rated) at operation point in trackless mines using diesel equipment, indirect injection engines and low emission fuel.

- 0.094-0.47 m^3/s /man underground.
- 0.024-0.094 m^3/s /ton of ore and waste.
- 0.032-0.126 m^3/s /kW of operating diesel power
- 0.035-0.070 m^3/s /kW installed diesel equipment.
- 620-935 m^3 /litre diesel fuel consumed.
- One complete air change between shifts in the operating section of the mine.

“Rules of Thumb” Caveat:

- These factors should **ONLY** be used as a guideline - in the final analysis, a mine’s ventilation requirements are dictated by occupational health and safety standards (TLVs).
- Failure to do so can be very hazardous - reliance on practices in comparable mines can lead to catastrophic consequences, and under or over designed ventilation systems.
- These “Rules” do not take account of the **efficiency of the ventilation system**, heat and radiation.

Ventilation system efficiency:

Ventilation efficiency % =

$$\frac{\text{Air reaching working faces (first pass) } (m^3/s) \times 100}{\text{Total mine air volume } (m^3/s)}$$

- Efficiency dependent on pressure difference, old workings, seals, distance to face from shaft, mining method.
- Many large deep mines work with efficiencies of 50% but this is relative.
- Low efficiencies are an indication of excessive leakage through non-working areas.

Transient losses (whole mine):

5%	• Horizontal cut-and-fill, narrow vein, backfilled, good bulkheads & seals.
25-30%	• Horizontal cut-and-fill, narrow vein, backfilled, fair bulkheads & seals.
40-50%	• Gravity type block cave mines.
50-90%	• Room-and-pillar mines.
70%	• Coal mines.

Leakage factors :

Shaft delivery systems
- up to 5% of main fan quantity in addition to planned leakage.

Intake Airways
- up to 15% of main fan quantity.

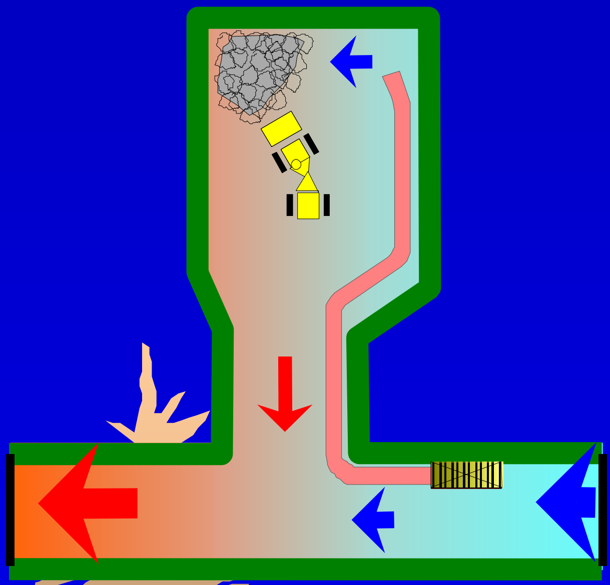
Stopes (open)
- typically 50% or more of the air supplied to a stope entry is lost before it reaches the face.

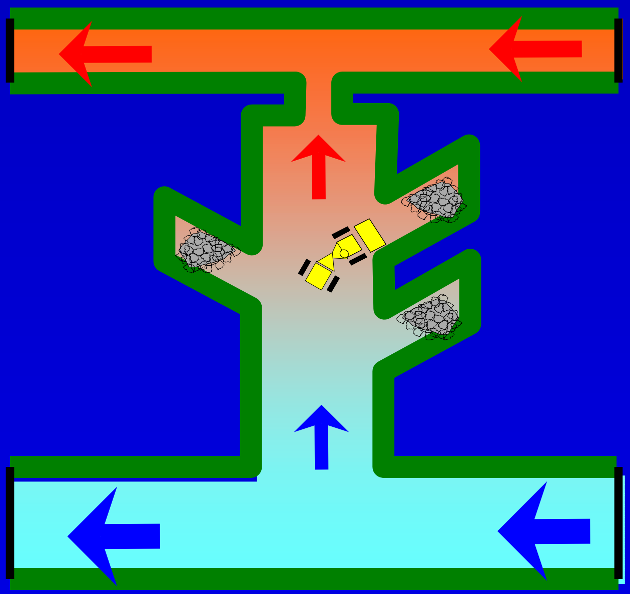
Stopes (backfilled)
- with backfilling this value reduces to 25% or more.

Leakage Caveat:

- **Even within a single mining method the transient losses can vary widely.**
- **Leakage factors can be used in estimating total ventilation requirements, but strict reliance can be dangerous as leakage is a function of the quality and maintenance of doors and bulkheads, their population and the pressure across them.**

Ventilation regimes:





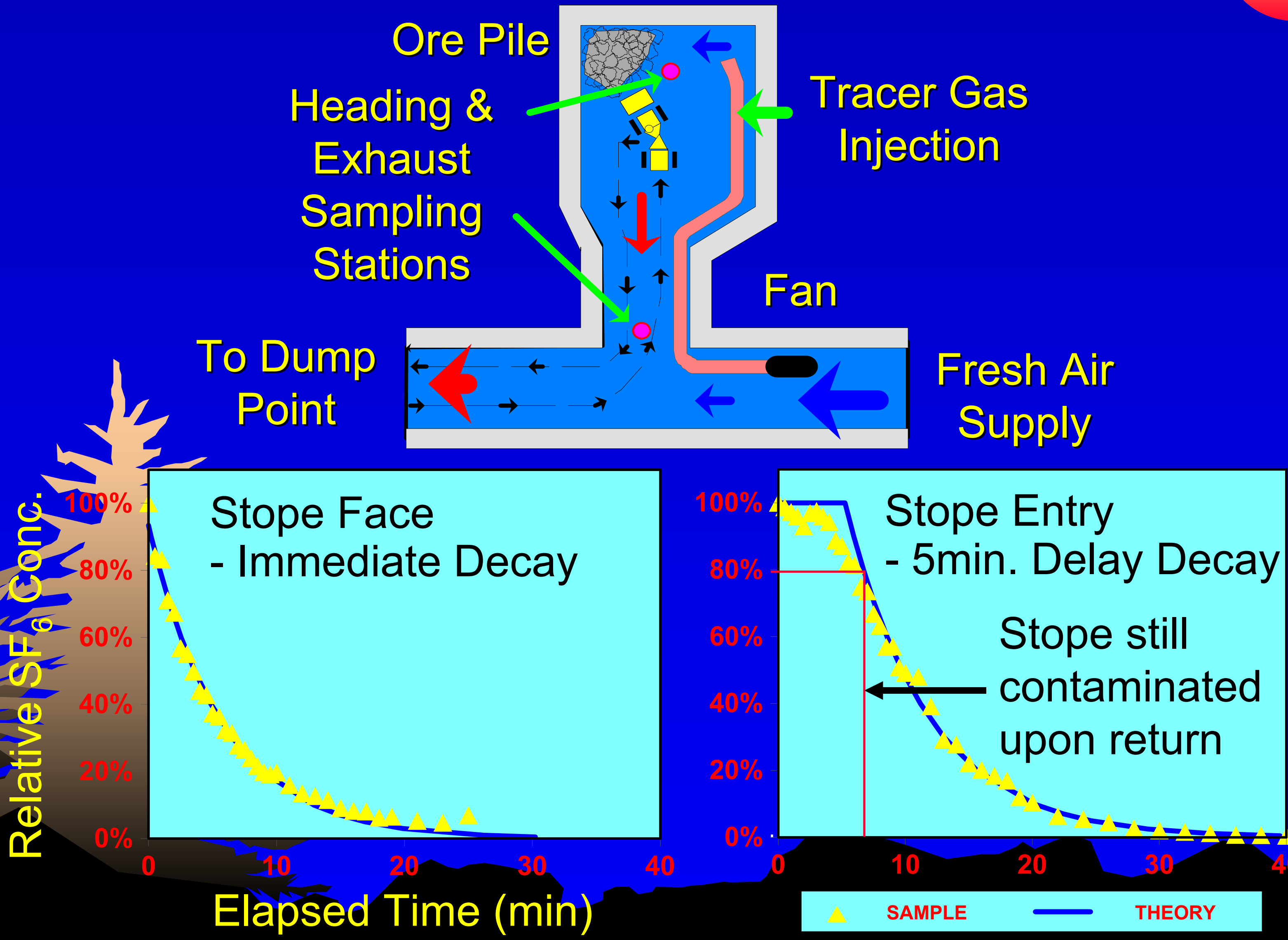
Mining scenarios & ventilation effectiveness

Room & pillar, cut & fill, vertical drawpoint, devlp. drivage

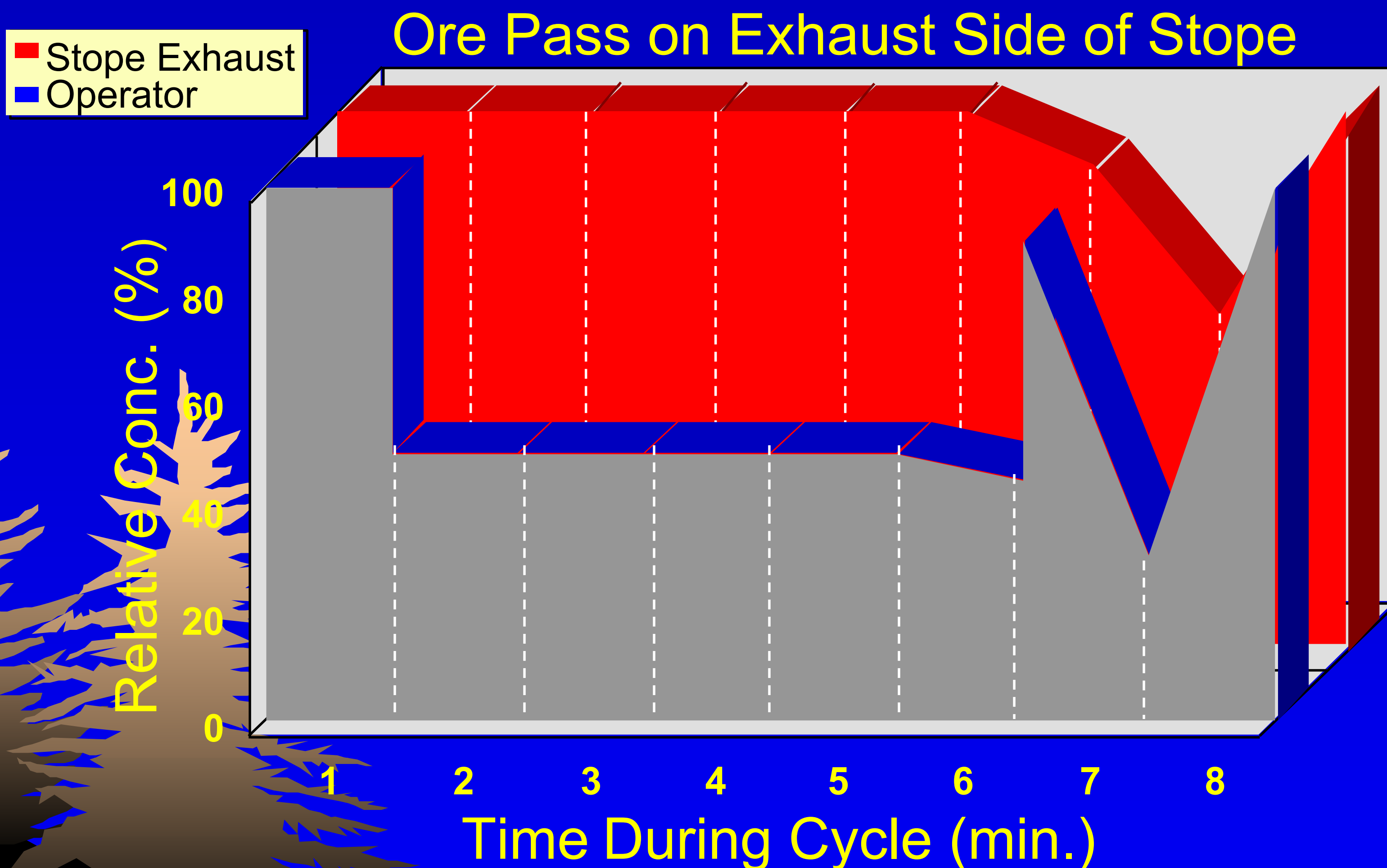
Ventilation method & operator relationship

Through ventilation, series ventilation

Ventilation effectiveness:



Operational layout:



Average Exposure 76% of Stope Condition

To & From Cycle 35% of Stope Condition

Conclusion:

The need to ventilate mines has been recognized for centuries and this need will continue.

Despite this, there is no "one-size fits all" in regard to ventilation design.

However the most common starting points are still diesel exhaust dilution requirements and heat mitigation.