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# Land-Based Gas Turbine Particulate Emissions

Effects, Regulations and Measurement  
Methods

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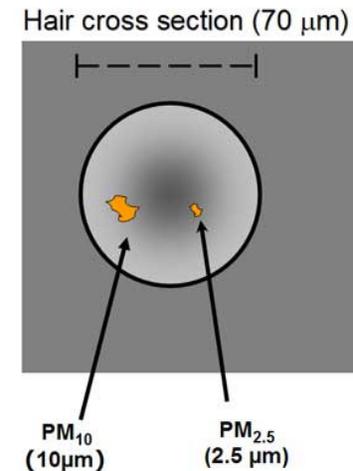


# Particulate Emissions

- Aims and Objectives
  - What are particulates?
  - How are they formed in combustion
  - Health & Environmental Effects
  - Legislation
  - Current Measurement Techniques

# Particulate Matter

- Complex mixture of solid particles and liquid droplets
- Defined by size range
  - $PM_{10}$
  - $PM_{2.5}$
  - Ultrafine particles
- Ultrafine particles make up a small proportion by weight, but a large proportion by number



<http://www.pscleanair.org/airq/basics/criteria/particulate.aspx>



# Formation of Particulates in the Combustion Process

- Combustion devices are a significant source of ambient  $PM_{2.5}$ 
  - Large particles tend to stay within the combustion system
- Formation of particulate matter in combustion
  - Volatilisation and homogeneous condensation form fly ash
  - Diameters between  $<1 \mu m$  to  $10 \mu m$
  - Coarser particles formed as result of agglomeration, growth and transport of smaller particles



## Health Effects

- Link between particulate matter and mortality known since winter smogs in 1940s and 1950s
- Significant impacts on human health
  - Respiratory inflections
  - Cardiovascular and Pulmonary disease
  - inflammation in the alveoli in the lungs
  - increase the coagulability of the blood
- $PM_{10}$  and  $PM_{2.5}$  have ability to cause oxidative stress in cell-free systems



# Mechanism for Causing Harm

- Studies provide measurements of different parameters:
  - particle mass,
  - size,
  - Number and concentration
  - concentration of species
- Mechanisms for causing harm
  - Dependence on size, surface area, mass or composition

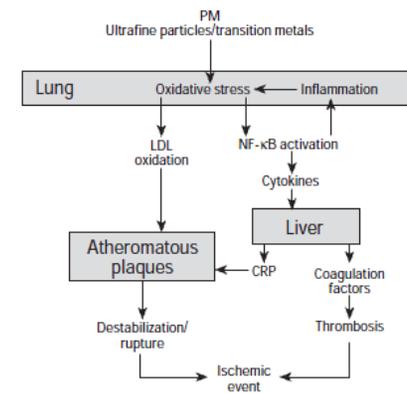


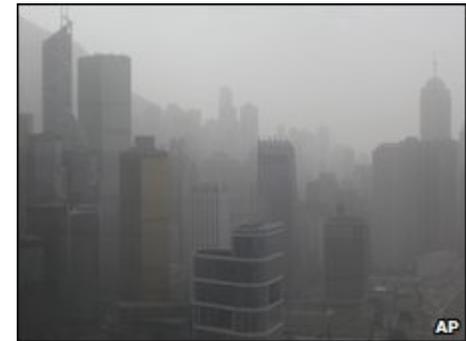
Figure 1. Diagram of the hypothetical events leading from deposition of particles in the lungs to ischemic events.

(Donaldson et al, 2001)



# Environmental Effects

- Several impacts on environment
  - Deposition, corrosion
  - Changes to the hydrological cycle
  - Damage to crops and vegetation
  - Reduced visibility
  - Nutrient depletion
- Highly dependent on number concentration and size distribution



[www.bbc.co.uk/news](http://www.bbc.co.uk/news)



## Relevant Legislation

- European Union
  - Large Combustion Plant Directive (2001/80/EC)
  - National Emissions Ceilings for Certain Atmospheric Pollutants (2001/81/EC)
  - Air Quality Standards
- USA
  - Clean Air Act
- United Nations
  - UNECE Convention on Long Range Transboundary Air Pollution





# Measurement Techniques

- Three main areas for investigation
  - Mass concentration (total particulate mass, mass of  $PM_{10}$ , mass of  $PM_{2.5}$ , mass of carbon), and the distribution of mass fractions between these
  - Particle number concentrations and particle size distribution by the number concentration
  - The morphology of the particles (shape, surface area, colour and optical properties)



# Measurement Techniques

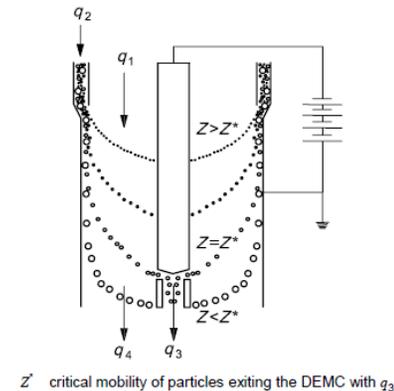
- Gravimetric methods are used to determine total particulate mass and mass fractions
  - Filter Paper Method
  - Quartz Crystal Microbalance
- Smoke Number
- Beta Gauge
- Scanning Electron Microspectroscopy
  - Particle size distribution and characteristics



# Measurement Techniques

- Differential Electrical Mobility Analyser

- Measures Size distribution
- Electrically charged particles will be attracted to electrodes and can be classified

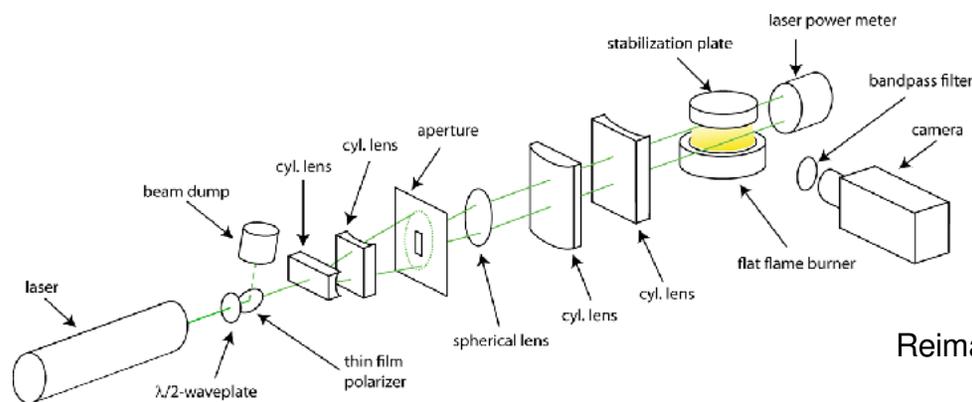


ISO 15900:2009

- Impactor and Cyclone Methods

- Separation of particles according to aerodynamic diameter

- Laser-Induced Incandescence
  - Optical technique
  - Uses a laser to induce particles to emit blackbody radiation
  - Emission of light can be measured using a photometer



Reimann, et al, 2009



E-Futures

## References

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- [www.durag.com](http://www.durag.com)