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Stack gas flow rate measurement at coal fired power stations

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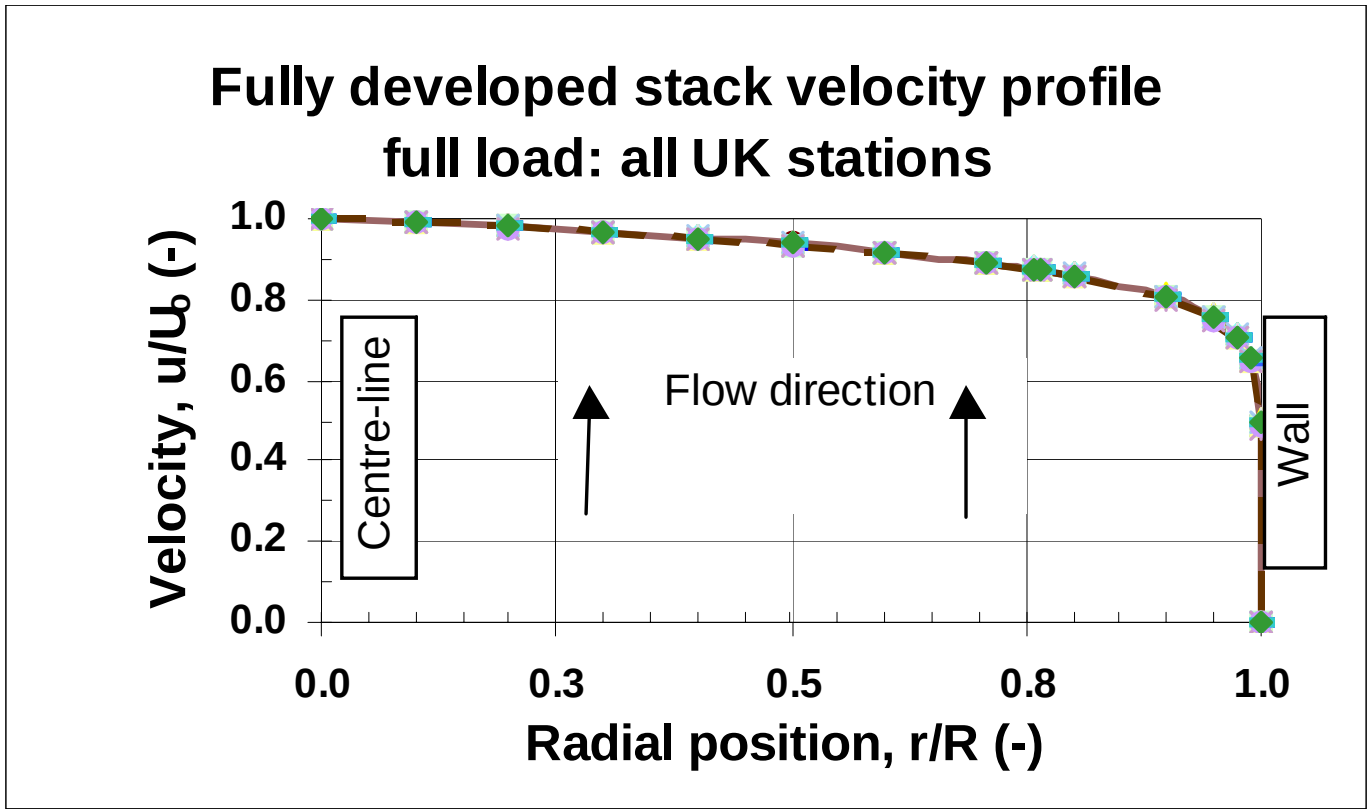
Background – UK and Europe

- **Stack flow is calculated** – for carbon trading/emissions reporting
- **Practical difficulties** - on large (8m) stacks, shared stacks, ageing plant
- **No standard CEN reference methods**
  - Velocity measurement standards - unsuitable for stacks
  - Recommended measurement locations are often impractical (e.g., BS 1042)

Coal fired power stations – idealised situation

- Fully developed turbulent velocity profile – well understood
- Profile shape very insensitive to load at typical Re numbers

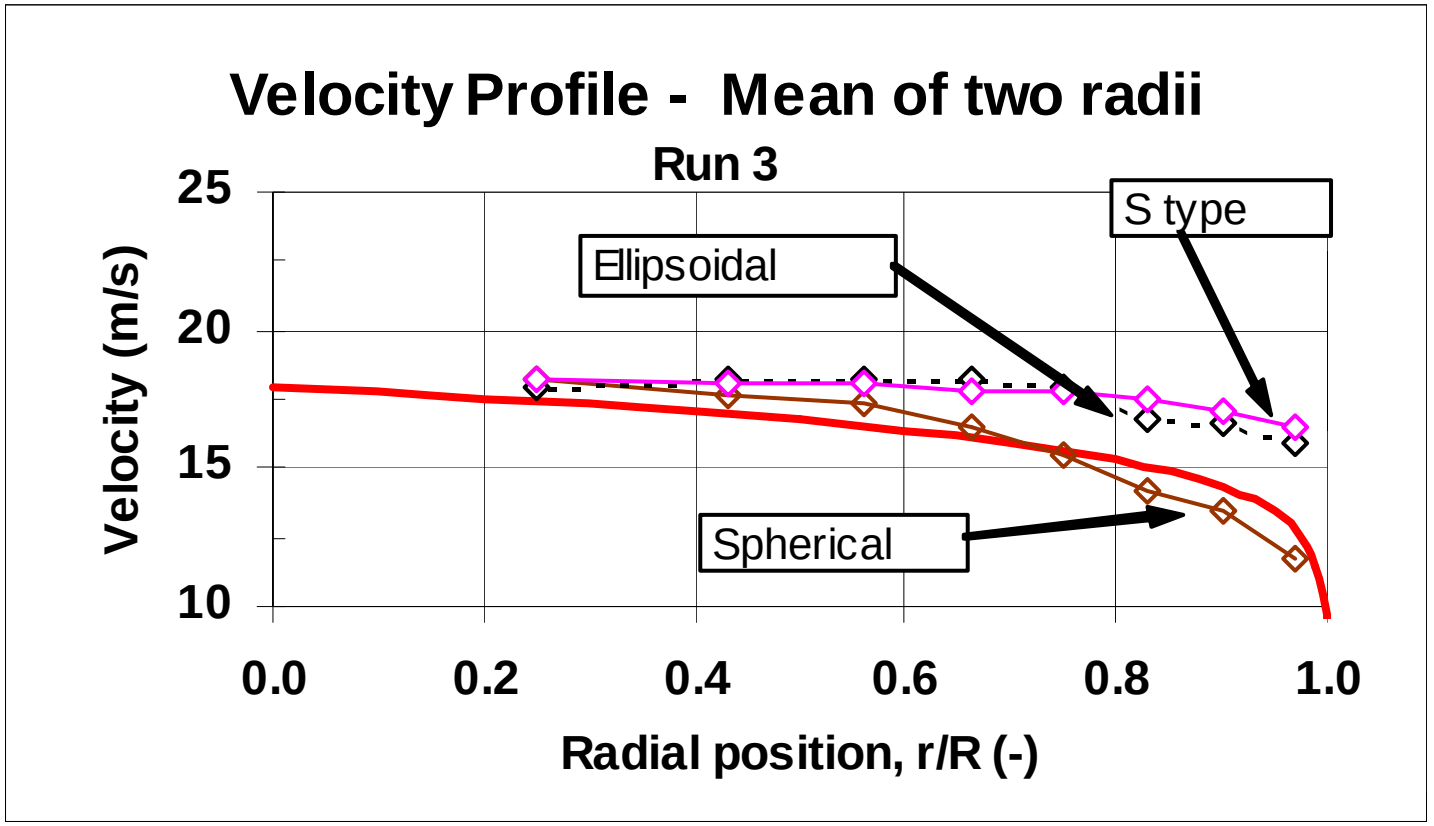


Coal fired power stations – typical 500 MWe Unit

Stack diameter	D	m	7.6
Mean velocity	U	m/s	16.0
Gas temperature	T	°C	134
Molecular mass	MM	kg/kmol	29.5
Gas density	ρ	kg/m^3	0.883
Gas viscosity	μ_{air}	kg/ms	2.3E-05
Reynolds no. (mean)	Re_U	-	4.7E+06
Mean vel/C-line vel	U/Uo	-	0.871
Centre-line velocity	Uo	m/s	18.4
Reynolds no. (c-line)	Re_{Uo}	-	5.4E+06
Radial position for average velocity	r/R	-	0.765

Comparison of ‘S’ type with 3D Spherical Pitot - Station A

Flow variation +13% due to swirl velocity component



Disadvantages of a velocity based approach

- **Not a direct measure of flow rate** – multi-point traversing required
- **Time-consuming –** stable plant operation required
- **Accurate stack flow area required**
- **Advanced Pitot methods** – calibration requirements

Development of a tracer injection approach

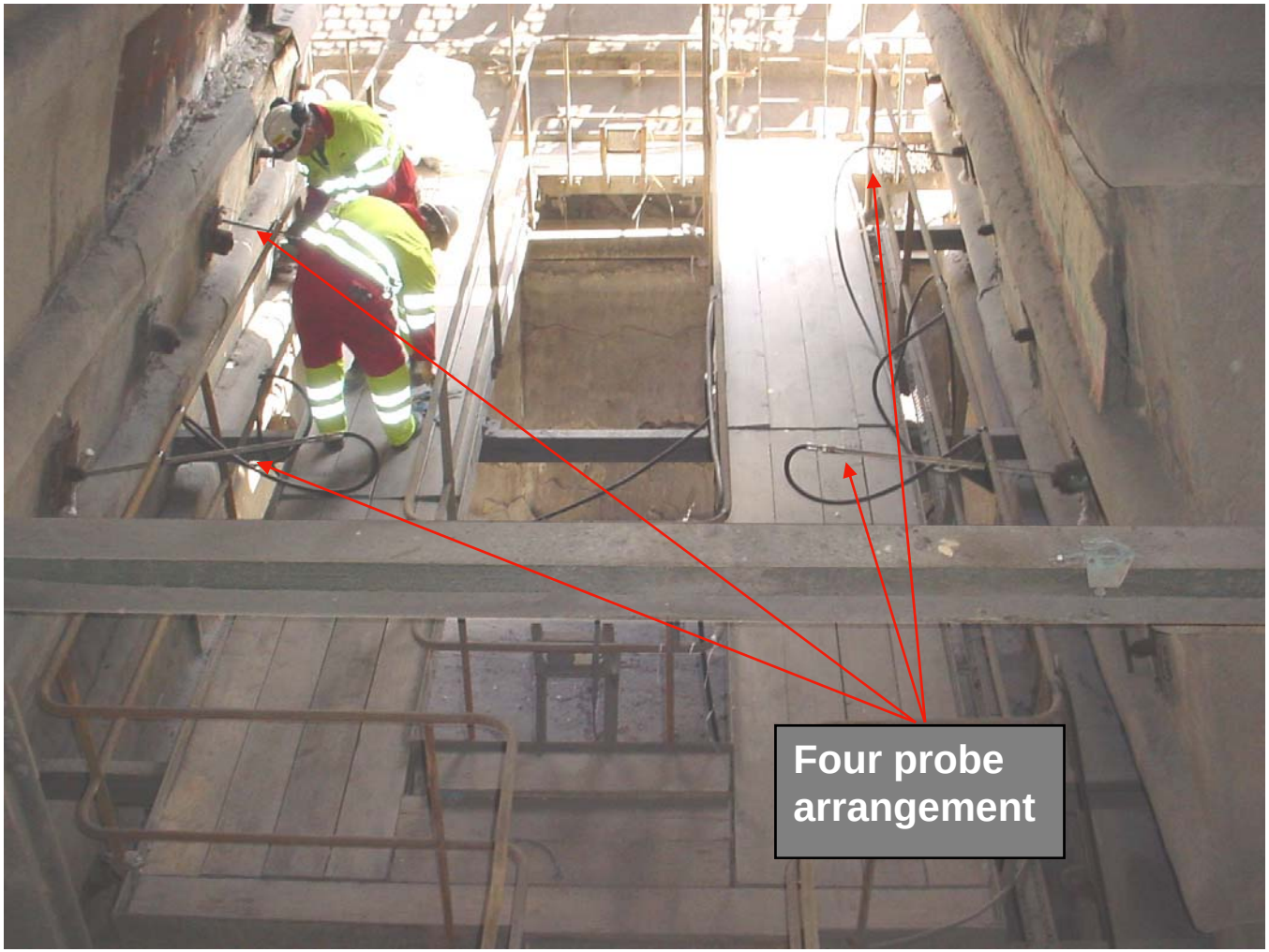
- **Mass flow tracer injection upstream of ID fan(s)**
  - Typically 3 min duration
  - Low uncertainty ±1%
  - Ensure even distribution to injection probes

- **Methane used as a tracer for coal stations**
  - FID hydrocarbon measurement
  - Calibrate with appropriate standard

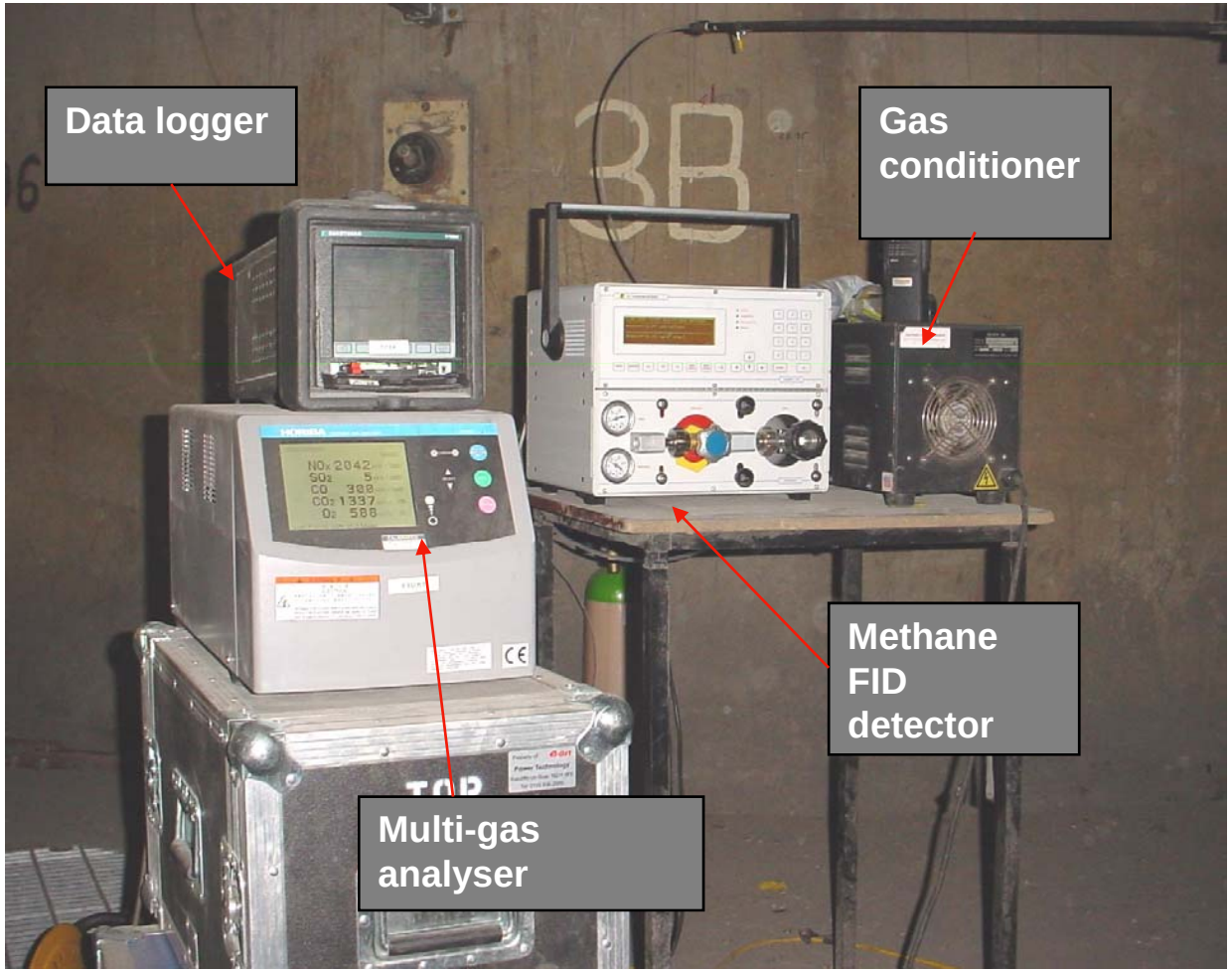
- **Multi-point sample probe in stack**

Tracer Injection

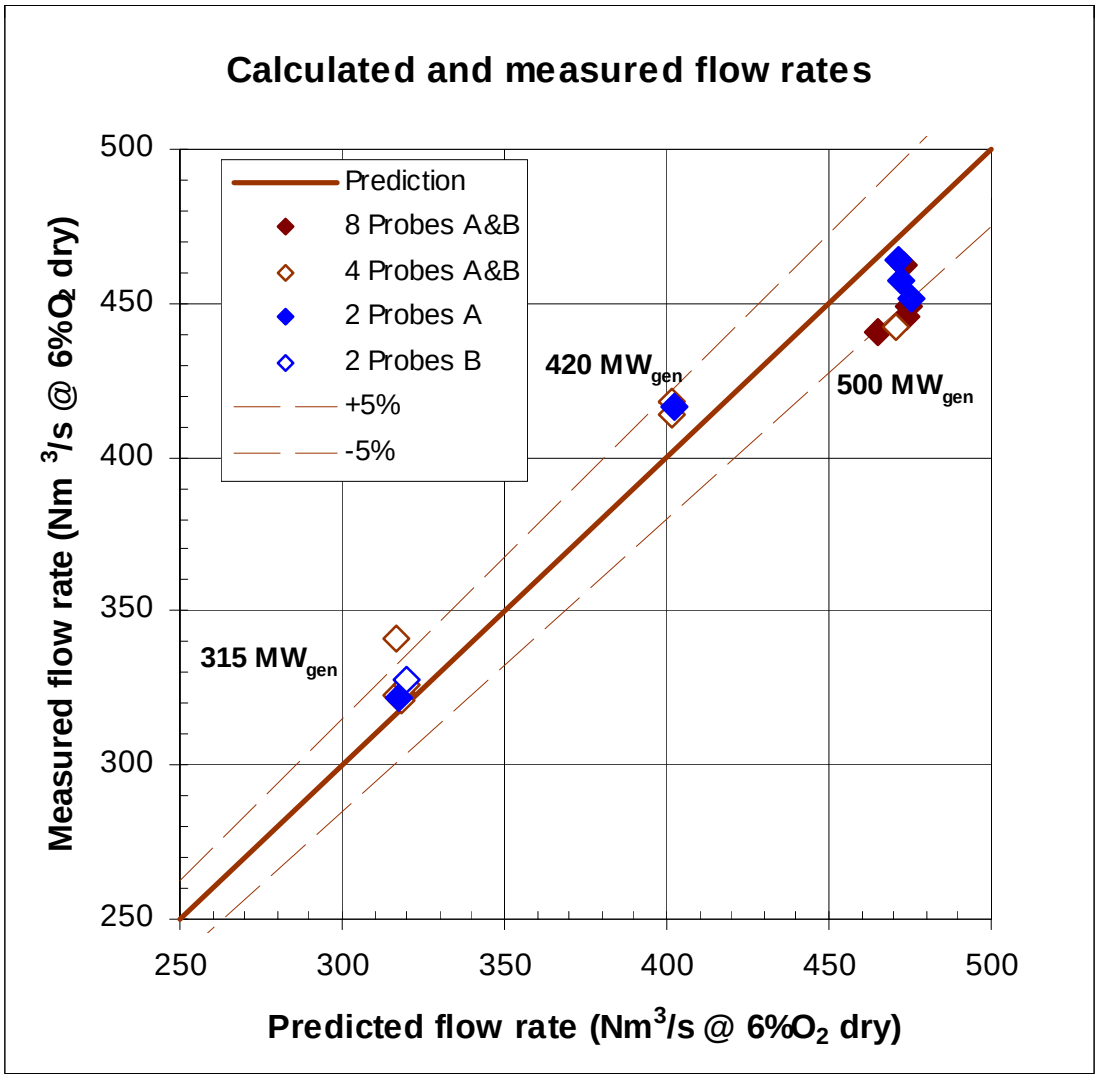
Tracer Injection



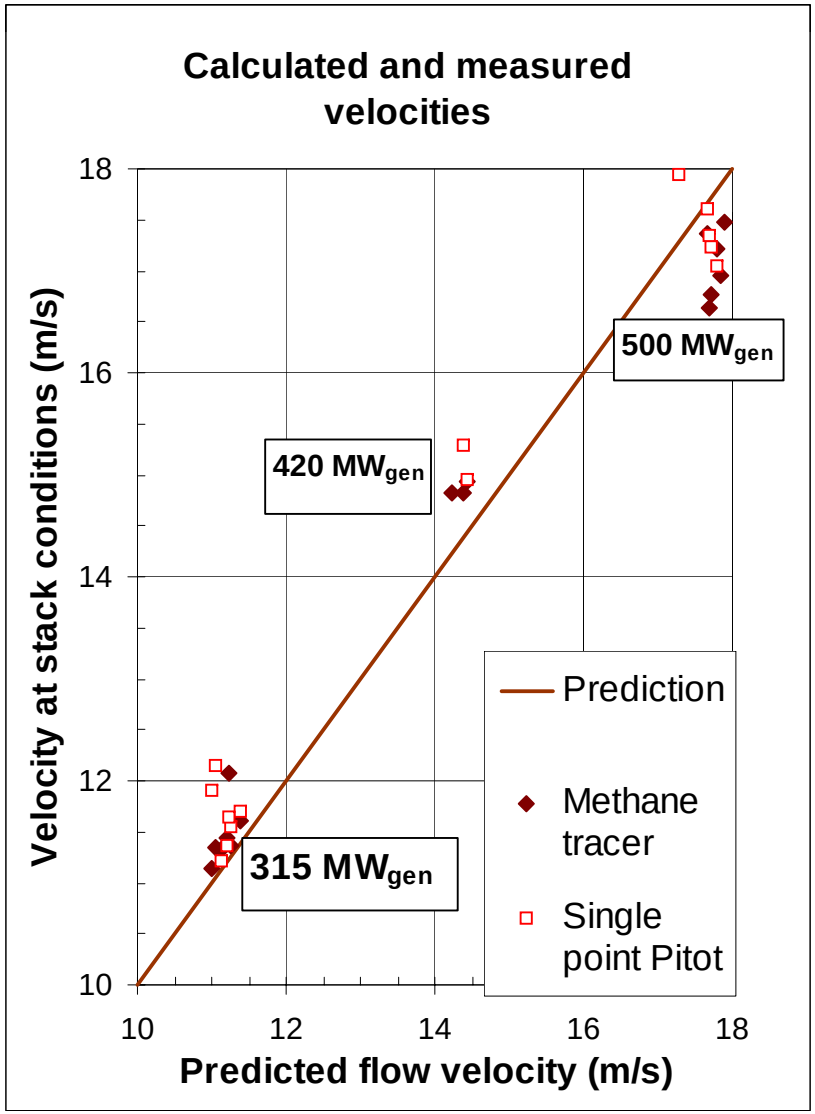
Tracer concentration measurement



Calculated and measured flow rates 500 MWe Unit



Calculated and measured velocities



Conclusions

- Advanced Pitot methods (US Methods) are required for accurate stack flow determination in typical coal fired plant
- Tracer injection techniques offer some advantages (direct flow measurement)
- Initial results using a methane tracer approach are promising
- Other tracer gases/detection methods should be investigated