IED RELATING TO OIL AND GAS BURNERS
FOR INDUSTRIAL USE

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JOINT MEETING OF THE COAL RESEARCH FORUM, (CRF), ENVIRONMENT DIVISION, THE
COMBUSTION ENGINEERING ASSOCIATION, (CEA) AND THE ROYAL SOCIETY OF CHEMISTRY
ENERGY SECTOR, (RSC-ES)

IMPERIAL COLLEGE LONDON - THURSDAY 22nd SEPTEMBER 2011.
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EU Directive 2010/75/EU

- Industrial Emissions Directive (IED)
- Integrated Pollution Prevention and Control (IPPC)
- Member States transpose into National Laws
Combination of Existing Directives into IED

- Large Combustion Plant directive (LCPD);
- Integrated Pollution Prevention and Control directive (IPPCD)
- Waste Incineration directive (WID)
- Solvent Emissions directive (SED)
- Other directives relating to Titanium dioxide
UK Timetable

- Transposition into UK law by 6 January 2013
- New plant compliance from 6 January 2013
- Existing installations (but not existing LCP) comply by 6 January 2014
- Other activities not currently part of IPPC comply by 6 July 2015
- Existing LCP compliance from 1 January 2016
## Large Combustion Plant – NOx Emissions

### Emission Limits - Oil Firing

<table>
<thead>
<tr>
<th>Thermal Input</th>
<th>New Plant</th>
<th>Existing Plant</th>
</tr>
</thead>
<tbody>
<tr>
<td>50-100 MW</td>
<td>300</td>
<td>450</td>
</tr>
<tr>
<td>100-300 MW</td>
<td>150</td>
<td>200</td>
</tr>
<tr>
<td>&gt;500 MW</td>
<td>100</td>
<td>150</td>
</tr>
</tbody>
</table>

### Emission Limits - Gas Firing

<table>
<thead>
<tr>
<th>Fuel</th>
<th>New Plant</th>
<th>Existing Plant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural Gas</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Other (includes COG and BFG)</td>
<td>100</td>
<td>200</td>
</tr>
</tbody>
</table>
Large Combustion Plant – Dust and CO Emissions

Particulate (dust) and CO emissions apply equally to new and existing plant

<table>
<thead>
<tr>
<th>Emission Limits - Oil Firing</th>
<th>Emission Limits - Gas Firing</th>
</tr>
</thead>
<tbody>
<tr>
<td>dust in mg/Nm³ (corrected for dry gas at 3% oxygen)</td>
<td>dust and CO in mg/Nm³ (corrected for dry gas at 3% oxygen)</td>
</tr>
<tr>
<td>Thermal Input</td>
<td>Fuel</td>
</tr>
<tr>
<td>50-100 MW</td>
<td>General</td>
</tr>
<tr>
<td>100-300 MW</td>
<td>BFG</td>
</tr>
<tr>
<td>&gt;500 MW</td>
<td>Steel Industry Gas</td>
</tr>
<tr>
<td>dust</td>
<td>dust</td>
</tr>
<tr>
<td>30</td>
<td>5</td>
</tr>
<tr>
<td>25</td>
<td>10</td>
</tr>
<tr>
<td>20</td>
<td>30</td>
</tr>
</tbody>
</table>
Large Combustion Plant – SO₂ Emissions

SO₂ emissions apply equally to new and existing plant

<table>
<thead>
<tr>
<th>Thermal Input</th>
<th>SO₂ (mg/Nm³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>50-100 MW</td>
<td>200</td>
</tr>
<tr>
<td>100-300 MW</td>
<td>200</td>
</tr>
<tr>
<td>&gt;500 MW</td>
<td>150</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fuel</th>
<th>SO₂ (mg/Nm³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>General</td>
<td>35</td>
</tr>
<tr>
<td>LPG</td>
<td>5</td>
</tr>
<tr>
<td>COG</td>
<td>400</td>
</tr>
<tr>
<td>BFG</td>
<td>200</td>
</tr>
</tbody>
</table>

SO₂ in mg/Nm³ (corrected for dry gas at 3% oxygen)
What Can Be Achieved?

Typical Burners for Fire Tube Boilers
Individual Burners up to 25 MW

<table>
<thead>
<tr>
<th>Fuel</th>
<th>NOx</th>
<th>CO</th>
<th>SO₂</th>
<th>dust</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural Gas</td>
<td>&lt;80</td>
<td>&lt;5</td>
<td>n/a</td>
<td>&lt;5</td>
</tr>
<tr>
<td>Lpg</td>
<td>&lt;200</td>
<td>&lt;5</td>
<td>n/a</td>
<td>&lt;5</td>
</tr>
<tr>
<td>Gas Oil</td>
<td>&lt;180</td>
<td>&lt;50</td>
<td>n/a</td>
<td>&lt;20</td>
</tr>
<tr>
<td>HFO</td>
<td>&lt;550</td>
<td>&lt;100</td>
<td>1700 per 1% in fuel</td>
<td>&lt;150</td>
</tr>
</tbody>
</table>

Above emissions are achievable without post-combustion cleaning systems, i.e. based on low NOx burner technology only.
Packaged Burners for Fire Tube Boilers

- Gas, Oil and Dual Fuel Burner
  Sizes from 3 to 25 MW
- NOx reduction through air and/or fuel staging
- Low CO across turn-down range
- Wide turn-down range 6:1 or greater
- Excessive SO$_2$ and dust emissions only from HFO combustion – depend on fuel composition
- HFO NOx is higher due to N in fuel
What can be Achieved?

Typical Burners for Water Tube Boilers
Individual or Multi-Burner Installations
Burner Sizes from 3 to 100 MW
Multi-Burner Boilers up to 600 MW

Achievable Emissions – Power Burners

<table>
<thead>
<tr>
<th>Fuel</th>
<th>NOx</th>
<th>CO</th>
<th>SO₂</th>
<th>dust</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural Gas</td>
<td>&lt;100</td>
<td>&lt;5</td>
<td>n/a</td>
<td>&lt;5</td>
</tr>
<tr>
<td>Lpg</td>
<td>&lt;100</td>
<td>&lt;5</td>
<td>n/a</td>
<td>&lt;5</td>
</tr>
<tr>
<td>Gas Oil</td>
<td>&lt;100</td>
<td>&lt;50</td>
<td>n/a</td>
<td>&lt;20</td>
</tr>
<tr>
<td>HFO</td>
<td>&lt;350</td>
<td>&lt;100</td>
<td>1700 per 1% in fuel</td>
<td>&lt;100</td>
</tr>
</tbody>
</table>

Above emissions are achievable without post-combustion cleaning systems i.e. based on low NOx burner technology only.
Power Burners for Water Tube Boilers

- Gas, Oil and Dual Fuel Burner Sizes from 3 to 100 MW
- NOx reduction through air and/or fuel staging. BAT is less than 20 mg/Nm$^3$ of NOx gas firing
- Low CO across turn-down range
- Wide turn-down range 6:1 or greater
- Excessive SO$_2$ and dust emissions only from HFO combustion – depends on fuel composition
- NOx from HFO depends on fuel nitrogen but can be less than 350 mg/Nm$^3$ with low NOx burner technology
Factors Affecting Burner NOx Emissions

- Excess air
- Air Preheat
- Firing Intensity
  - Heat Release per Furnace Volume
- Turbulence and Mixing
- Fuel Composition
Post Combustion Emissions Reduction

- Costly systems applicable mainly for larger plant i.e. high pressure steam boilers
- In-furnace NOx reduction
- Flue Gas Acid Gas Scrubbing
- Dust Removal Systems
In-Furnace Systems

- **Flue Gas Recirculation (FGR)**
  - NOx reduction up to 75%
  - Some burners can use 30% or more FGR
  - Additional or larger fan required – increased electricity use
  - Increases mass flow

- **Water Injection through Burner**
  - NOx reduction up to 20%
  - Increases mass flow
  - Reduces efficiency

- **Steam injection in (Gaseous) Fuel**
  - NOx reduction up to 40%
  - Can use low pressure ‘waste’ steam
  - up to 0.5 kg / kg of fuel

- **Steam injection in Air**
  - NOx reduction up to 25%
In-Furnace Systems, *Continued*

- **Over-fire Air (OFA) or After Burner Air (AAP)**
  - Applicable for multi-burner systems
  - Air Ports above top row of burners
  - Burners operate sub-stoichiometrically
  - Use CFD to aid design
  - NOx reduction up to 40%

- **Row Staging**
  - Lower Burners operate sub-stoichiometrically
  - Higher burners operate with higher excess air
  - NOx reduction up to 10%
In-Furnace Systems, Continued

- Selective Non-Catalytic Reduction (SNCR)
  - In-furnace injection of ammonia or urea
  - Limited temperature window (900 to 1000 °C)
  - Not suitable for all applications
  - NOx reduction 40 to 80%
  - Risk of ammonia ‘slip’
  - Ammonia emission limit <5 mg/Nm³

- Re-burn
  - Similar to OFA but with additional gas burning downstream in furnace
Post Combustion Gas Cleaning

- **SO2 Removal**
  - Wet scrubbing
    - Packed bed or venturi
  - Dry scrubbing
    - Lime injection in bag house
  - Efficiency > 95% is possible

- **Dust Removal**
  - Bag House
  - ESP
  - Efficiency > 95% is possible
Post Combustion Gas Cleaning

NOX Reduction

- Selective Catalytic Reduction (SCR)
  - Injection of ammonia or urea
  - Catalyst bed to achieve efficiency
  - Capable of operating at low temperature
  - Suitable for installation after boiler and heat recovery
  - NOx reduction >90%
  - Ammonia emission limit <5 mg/Nm³
Terms and Conditions

- For retrofit applications, specific limits may not always be achievable due to furnace shape and firing intensity.
- $\text{SO}_2$ and particulate emissions depend on fuel composition.
- 1% S $\rightarrow$ 1700 mg/Nm3 of $\text{SO}_2$.
- Ash in fuel is unchanged by combustion process.
# How Can NOx Limits Be Achieved?

## Emission Limits - Oil Firing

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<tr>
<td>50-100 MW</td>
<td>300</td>
<td>450</td>
<td>Can be achieved on some fire-tube boilers with gas oil and HFO firing and in-furnace techniques</td>
</tr>
<tr>
<td>100-300 MW</td>
<td>150</td>
<td>200</td>
<td>Requires SNCR or SCR systems for HFO combustion, low NOx burner technology for gas oil combustion</td>
</tr>
<tr>
<td>&gt;500 MW</td>
<td>100</td>
<td>150</td>
<td></td>
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## Emission Limits - Gas Firing

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</thead>
<tbody>
<tr>
<td>Natural Gas</td>
<td>100</td>
<td>100</td>
<td>Achievable with low NOx burner technology in all applications</td>
</tr>
<tr>
<td>Other (includes COG and BFG)</td>
<td>100</td>
<td>200</td>
<td></td>
</tr>
</tbody>
</table>

NOx limits are in mg/Nm³ (corrected for dry gas at 3% oxygen).
Summary

- Gas Firing Emission limits can generally be achieved with low NOx burner technology only - for most commercially available fuels
- Where fuels contain sulphur, ash or nitrogen (e.g. HFO) post combustion gas cleaning systems are almost certainly required
- Oil firing NOx emissions can generally be achieved with a combination of low NOx technology and in-furnace techniques
- Consideration of furnace and burner design together for new installations will be important for minimisation of emissions