Energy from Waste
Health and Safety Considerations
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General Manager
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from waste to resource
Health and Safety in a modern 170kt EfW plant

from waste to resource
Lincolnshire Energy from Waste
Site Layout

Fuel reception  Boiler  Flue Gas Cleaning  Turbine and ACC
Safety Considerations for EfW
Waste – the most diverse fuel to dream of

- Vast range of sources and consistency
  - Municipal Solid Waste (MSW)
  - C+I Waste (Commercial and Industrial)
  - Food Waste
  - Green/Garden Waste
  - Biogenic Waste – Biomass
  - Recycling Waste
  - Metals
  - WEEE
  - Liquids
Waste from a technical perspective

- A lot of sampling to get a “meaningful” result
- E.g. 5,000 kg – 13 vehicles

<table>
<thead>
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<tr>
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</tr>
<tr>
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<td>Gross CV</td>
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</tr>
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<td>Sulpher</td>
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<tr>
<td>Chlorine</td>
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Waste from a technical perspective

- This analysis does not account for trace materials like Lead, Cadmium, Zinc, Aluminium, Magnesium, Asbestos, PCB’s, Batteries, etc....
- But – you have to burn it as it comes...

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Waste from a technical perspective

- ... and it comes in different shapes
Waste from a technical perspective

• ... or conditions:
  – Waste heats up and burns – everywhere.
  
  – or it is soaking wet and does not burn/ignite
<table>
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<th>Hazard Category</th>
<th>Description</th>
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<tr>
<td>Exploding bomb</td>
<td>(for explosion or reactivity hazards)</td>
</tr>
<tr>
<td>Gas cylinder</td>
<td>(for gases under pressure)</td>
</tr>
<tr>
<td>Health hazard</td>
<td>(may cause or suspected of causing serious health effects)</td>
</tr>
<tr>
<td>Environmental hazard</td>
<td>(may cause damage to the aquatic environment)</td>
</tr>
<tr>
<td>Biohazardous infectious materials</td>
<td>(for organisms or toxins that can cause diseases in people or animals)</td>
</tr>
<tr>
<td>Flame (for fire hazards)</td>
<td></td>
</tr>
<tr>
<td>Corrosion (for corrosive damage to metals, as well as skin, eyes)</td>
<td></td>
</tr>
<tr>
<td>Exclamation mark (may cause less serious health effects or damage the ozone layer)</td>
<td></td>
</tr>
<tr>
<td>Skull and Crossbones (can cause death or toxicity with short exposure to small amounts)</td>
<td></td>
</tr>
</tbody>
</table>
The way to process waste in an EfW

- Visual inspection from the crane seat and tipping hall
  - you cannot beat Eyeball MK1
- Shred it, if oversized
  - but think of gas bottles!!
- Burn it...
  before it starts to burn
Process Safety Consideration

• Typical EfW combustion Systems:
  – Grate furnace
  – Fluidised Bed
  – Gasifiers (Fluidised Bed)

• Load and temperature control highly variable due to rapid changes in CV and waste moisture
• Oil/Gas burners to compensate for temperature drops
Process Safety Consideration

• In general fuel for 30 mins to 1 hour in the furnace
  – Shutdown conditions
    – Smouldering the fire by lack of oxygen
    – High CO
  – Boiler tubeleaks
    – The need to feed water until the fuel is burned off and/or ejected to avoid CO during repairs
  – Gas emissions in case of furnace over-pressurisation
The contact with waste

- Maintenance and cleaning of contaminated equipment is the biggest concern
  - PPE – Masks, Coveralls, Overshoes, Gloves, goggles/vizors
  - Cleaning detergents and disinfection sprays
  - Good hygiene
  - Housekeeping in waste affected areas
  - Dust management

- Continuous Pest Control (Rats, Flies)
Bulk Process Reagents - all COSHH

- **SNCR Reagent – Ammonia (Water) or Urea**
  - DSEAR relevance (not when in 25% solution)
  - PPE
  - Housekeeping and Spillage Control

- **FGT Reagents – Ca-Hydrate and Activated Carbon**
  - Caustic properties for Ca-Hydrate
  - Need for PPE – Eyes, skin and respiratory
  - DSEAR and Fire relevance for Carbon
  - Housekeeping and Spill Control

- **WTP Reagents**

- **Nothing new in comparison to traditional power industry**
Process By-Products

- Flue Gas
- Incinerator Bottom Ash (IBA): the FBA of Waste
- Air Pollution Control Ash (APCR): the Fly Ash
Flue Gas and IBA
Flue Gas and APCR
Flue Gas (dirty)

- Chemical composition similar to any other combustion process, but...
  - Varying levels of Cl, Fl, S (e.g. from Plastics)
  - Varying levels of evaporated metals, e.g. Cd, Pb, Al,
  - Varying levels of CO, depending on combustion temperatures and O₂ levels in the furnace
  - NH₃ and/or NOₓ, if SNCR is not working correctly
  - Dioxin/Furan, unlikely but possible if 850°C are not met
  - High moisture, up to 25% H₂O
  - High dust levels
Flue Gas (dirty)

- Flue gas is therefore highly acidic
  - Fireside corrosion on unprotected heat transfer surfaces
  - Corrosion on steelwork if dew point is not met
- Flue gas can affect staff if sufficient suction is not maintained
  - Increased CO levels in the boiler house
  - Dust release containing heavy metals
  - Smell
Flue Gas (clean)

- Clean flue gas compliant with IED/WID after the baghouse, but still...
  - small levels of Cl, S
  - Varying levels of CO, depending on combustion temperatures and O₂ levels in the furnace
  - NOₓ, if SNCR is not working correctly
  - High moisture, up to 25% H₂O

- Still corrosive, but lesser an issue
What is APCR?

- Mix of fly ash, limestone and activated carbon
- Highly caustic, pH > 12
- Can contain traces of heavy metals
- Can contain NH$_3$
- Rated as Hazardous Waste and needs to be treated before disposal in a Landfill
• Handling of APCR
  – Enclosed systems, pneumatic conveying into a silo
  – Disposal via Road Tanker

• Minor Process Safety Relevance

• H+S relevance
  – Toxicity
  – Caustic Properties

  – Management by suitable PPE (Coveralls, Gloves, Dust masks,...
  – Housekeeping
• **What is IBA?**
  - Collection of fly ash from the boiler de-ashing
  - Grate ash/clinker
  - Metals 15-20%
  - Heavy metals
  - Waste, if not burned

• All IBA is quenched in the Ash Discharger and stored wet in piles before it is transported off site.
**Incinerator Bottom Ash (IBA)**

- **Risks with IBA**
  - Caustic, pH 12 (ish)
  - Can contain Heavy Metals, but dispersed and diluted, so non toxic in most cases
  - Can contain Waste
  - Contains Metals – Fe, Al, Mg
  - And water...

- **Any issues?**
Incinerator Bottom Ash (IBA)

- IBA can release Hydrogen
- IBA can generate local explosions
Process Safety Incidents with IBA

- Explosion in the hold of a general cargo vessel carrying incinerator bottom ash while at anchor off Plymouth 13/01/17. 1 crew member was seriously injured.

- Various events in wet de-ashing systems of EfW plants worldwide over the last 20 years

- The driver is that Hydrogen gas is released from the IBA during the ageing process as Aluminium reacts with Calcium Hydroxide and water to form Aluminium Hydroxide.
Management of IBA

• Application of DSEAR Regulations
  – DSEAR Assessment
  – Fixed Ash discharger ventilation
  – Building Ventilation
  – H$_2$ sensors if accumulations possible
  – Short Term Storage inside or outside

  – Risk is manageable and therefore not an issue (anymore)
Management of ashes (general)

- Frequent sampling and analysis to prove levels of toxicity and consistency
- Reporting to the EA, together with the gaseous emission declarations
- As it is waste – falls under the Duty of Care process and is fully monitored with waste transfer notes and consignment notes.
- Established process in line with EA protocols
Conclusion

- Process safety comparable to the operation of small solid fuel fired boiler plant.
- Fuel consistency introduce a vast spectrum of additional chemical risks which are addressed.
- Process By Products need careful consideration due to chemical consistency.
- Housekeeping and H+S control is essential to maintain a safe environment like any other plant.
Any Questions?

from waste to resource
Backup

from waste to resource
## Emission Limit Values

<table>
<thead>
<tr>
<th>Substance</th>
<th>½ hr Average</th>
<th>Daily Average</th>
</tr>
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<tbody>
<tr>
<td><strong>CO</strong> (Carbon Monoxide)</td>
<td>100mg/m³</td>
<td>50mg/m³</td>
</tr>
<tr>
<td><strong>TOC</strong> (Total Organic Carbon)</td>
<td>20 mg/m³</td>
<td>10mg/m³</td>
</tr>
<tr>
<td><strong>NOx</strong> (Nitrogen Oxides)</td>
<td>400mg/m³</td>
<td>200mg/m³</td>
</tr>
<tr>
<td><strong>SO2</strong> (Sulphur Dioxide)</td>
<td>200mg/m³</td>
<td>50mg/m³</td>
</tr>
<tr>
<td><strong>HCl</strong> (Hydrogen Chloride)</td>
<td>60mg/m³</td>
<td>10mg/m³</td>
</tr>
<tr>
<td><strong>Dust</strong></td>
<td>30 mg/m³</td>
<td>10mg/m³</td>
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Design Parameters

**Design**

- Original design 150,000 tpa (7,800 operational hours)
- Upgraded permit for 170,000tpa since October 2015
- 19.24 t/h throughput
- Waste CV = 9.3 MJ/Kg (Range 7.2 – 13 MJ/Kg)
- 13.1 MWe (Export 11.2 MWe)
- 10 MW thermal (District Heating)
- Bottom Ash 31,000 tpa (3,000 t metals)
- APCR 6,000 tpa

**Results 2015**

- 164,518 t
- Availability 90.97% (7969 hours)
- 20.64 t/h throughput
- Waste CV = 8.14 MJ/Kg
- 12.2 MWe (Export 9.97 MWe)
- Bottom Ash 38954 tpa (6,200 t metals)
- APCR 4032 tpa
Start up
Waste Burn
Combustion Diagram