Adjusting Pipeline Gas Composition to Simplify Metrology

Peter Martin
Peter Carnell
Rachel Mansfield
Composition of Pipeline Gas

- Mainly methane but also higher hydrocarbons and aromatics
- Carbon dioxide
- Nitrogen
- Oxygen
- Sulphur compounds - Contaminant
- Mercury
- Siloxanes – (ex landfill gas)
Meeting Pipeline Specifications

- Gas specifications historically set for domestic market
- Main Criteria
  - Higher Heating Value (HHV)
  - Wobbe Number
- Diverse applications
- Criteria of increasing importance:
  - Chemical Composition
Issues

Natural gas composition (over 3.5 months)

- Ethane
- Propane
- Hydrogen sulfide

H₂S
Hydrogen Sulfide

Siloxane “MM”

Siloxane “D4”

Rn²²²
Mercury

Puraspec
Gas Variability of Pipeline Gas

- Mainly methane but also some higher hydrocarbons and aromatics
- Carbon dioxide
  - No HHV + Reduction in pipework capacity
  - Can lead to corrosion in the presence of condensed water
- Nitrogen
  - No HHV + Reduction in pipework capacity
  - Leads to NH₃ formation on steam reformers
- Oxygen
  - Can lead to corrosion in the presence of condense water
  - Elemental S formation – fouling of adsorbent beds and instrument tapping points

Table 1: Typical Composition for Natural Gas Distributed in Germany

<table>
<thead>
<tr>
<th>Gas Composition</th>
<th>Unit</th>
<th>Russian Group H</th>
<th>North Sea Group H</th>
<th>Danish Group H</th>
<th>Libya LNG (rich)</th>
<th>Nigeria LNG (mean)</th>
<th>Egypt LNG (lean)</th>
<th>Bio-methane</th>
<th>Bio-methane + LPG</th>
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</thead>
<tbody>
<tr>
<td>Methane</td>
<td>mol%</td>
<td>96.96</td>
<td>88.71</td>
<td>90.07</td>
<td>81.57</td>
<td>91.28</td>
<td>97.70</td>
<td>96.15</td>
<td>90.94</td>
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<tr>
<td>Nitrogen</td>
<td>mol%</td>
<td>0.86</td>
<td>0.28</td>
<td>0.08</td>
<td>0.69</td>
<td>0.69</td>
<td>0.69</td>
<td>0.75</td>
<td>0.69</td>
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<tr>
<td>Carbon Dioxide</td>
<td>mol%</td>
<td>0.18</td>
<td>1.94</td>
<td>0.60</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>2.90</td>
<td>2.68</td>
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<tr>
<td>Ethane</td>
<td>mol%</td>
<td>1.37</td>
<td>6.93</td>
<td>5.68</td>
<td>13.38</td>
<td>4.62</td>
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<tr>
<td>Propane</td>
<td>mol%</td>
<td>0.45</td>
<td>1.25</td>
<td>2.19</td>
<td>3.67</td>
<td>2.62</td>
<td>0.22</td>
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<td>5.00</td>
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<tr>
<td>n-Butane</td>
<td>mol%</td>
<td>0.15</td>
<td>0.28</td>
<td>0.90</td>
<td>0.69</td>
<td>1.40</td>
<td>0.20</td>
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<td>0.50</td>
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<tr>
<td>n-Pentane</td>
<td>mol%</td>
<td>0.02</td>
<td>0.05</td>
<td>0.22</td>
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<td>-</td>
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<td>-</td>
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<tr>
<td>n-Hexane</td>
<td>mol%</td>
<td>0.01</td>
<td>0.02</td>
<td>0.06</td>
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<tr>
<td>Hydrogen</td>
<td>mol%</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.20</td>
<td>-</td>
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<tr>
<td>Oxygen</td>
<td>mol%</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.19</td>
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<tr>
<td>Total</td>
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<td>100.00</td>
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</tr>
</tbody>
</table>
Sulphur – H$_2$S

- Pipeline specification – Variable around the world
  - 0.25grains/100SCF (3.8ppm v) North American standard
  - 3.3ppm v (5mg/m3) European Standard
  - 1ppm v suggested to avoid black dust formation
- Black dust causes major operational problems in the gas industry
  - Product contamination, erosion, clogging, fouling
  - Health and environmental issues

Images: Review of black powder in gas pipelines e An industrial perspective
Sulphur – H₂S Cont…

• Variable with different pipelines
• Removal required
  • Eliminate black dust
  • Reduce emissions control
    • < SOₓ pollution and < deterioration of abatement systems
• Feedstock purity – into catalytic processes
• Elemental S formation leading to equipment fouling
Mercury - Hg

- Present in geological formations
Mercury - Hg

- Present within produced natural resources
  - Oil and Gas
- No legislation
- Specifications implemented due to other factors
  - 10ng/Nm3 typical specification – Set by historic level of detection
  - Hazardous to health and the environment
  - Release to atmosphere on combustion
  - Catalysts poison
  - Attack on some metal alloys leading to failure
Siloxanes

- Mainly stemming from landfill gas
  - Organosilicon compounds formed in biological activity
- Problems with gas engines
  - Melts and deposits in a glass like layer
  - Rotating equipment damaged
  - Exhaust management systems damaged
Radioactive Materials

- Another contamination issue with gas pipelines is presence of radioactive materials, i.e. Radon
- Bulk Radon is removed during processing of natural gas
- Presence of such materials creates a potential hazard to personnel, public and environment
- Introduces requirement for NORM, Naturally Occurring Radioactive Material, measurements
  - Guidelines for NORM monitoring
  - Identification & assessment of risks
  - Control measures
  - Disposal procedures
Variable gas quality impacting engine performance

- Chemical composition influences the combustion behaviour and knocking characteristics of a fuel
  - Knock characteristics are specific to gas composition
  - Methane Number is calculated to indicate resistance of the fuel to end gas knock and ignition capability
- Gas engines are designed to accept, within design limits, a wide range of gas quality, but fluctuating fuel quality affects performance:
  - Engine knock
  - Reduced Efficiency
  - Increased emissions
  - Damage to engine
Variable gas quality impacting exhaust temperatures for gas turbine engines

- Variable gas composition affect the exhaust temperature of gas turbine engines in ACC Power plants
- Increased heat release from the combustion of heavier hydrocarbons
- Temperatures in excess of 1600oC can be attained
- Turbine blade integrity is impacted at these temperatures
  - Blade damage
Variable gas quality impacting Burners

- Variability in feed gas composition affects:
  - Flame shape
  - Flame height
  - Luminosity

- Variability is posing great challenges for the glass and ceramic industry

- Furnace control
  - Time/Temperature
  - Shaping step
    - Out of Spec glass
The Solution

- Catalytic route to converting higher HCs to methane
- Precious metal catalyst system
- Hydrogen addition achieved through steam addition
Solution

- The move to LNG as the source of pipeline gas would allow higher standards of purity
- Change to a “chemical specification” for pipeline gas – is a near 100% methane target achievable?
- Use CDR to convert heavy hydrocarbons to methane
- Use fixed bed absorbents for total H₂S and Hg removal
- Switch to non-sulphur odorants.
- Questioning specifications placed on “green” initiative gases eg bio-gas and land-fill gas