Methane to Markets Partnership Expo

Beijing, China

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CATERPILLAR®

利用垃圾填埋气
-- 气体预处理方案的评价

罗伯特 莎福纳
卡特彼勒电力集团

Dealing with Landfill Fuels: Evaluating Fuel Treatment Options

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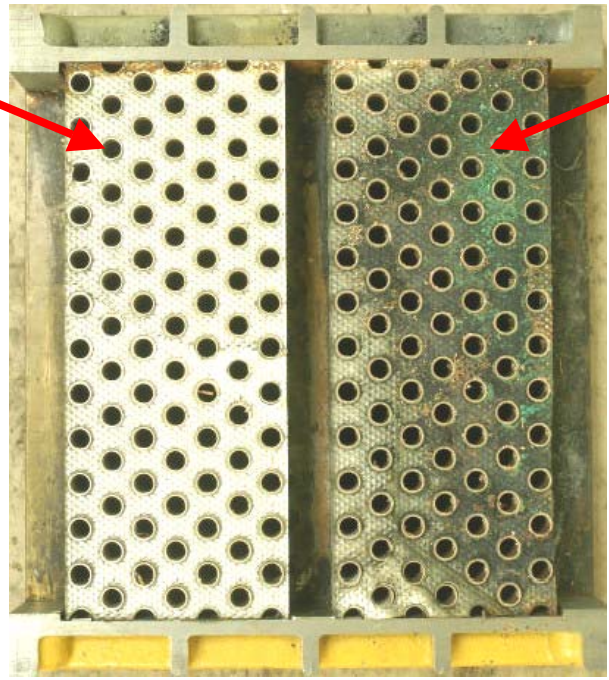
Contaminants

- Landfill gas contains corrosive and abrasive contaminants
  - Corrosive contaminants
    - Sulfur compounds
    - Halide compounds
  - Abrasive contaminants
    - Silicon compounds

Contaminants And Their Impact

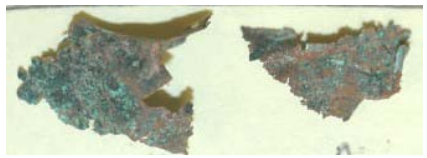
- **Hydrogen Sulfide, H_2S**
  - Forms sulfuric acid
    - Corrodes metals containing copper

1st Stage Aftercooler Core- Warm



2nd Stage Aftercooler Core- Cooler Area Condenses Water in Fuel/Air Mixture

Copper Aftercooler Core Unaffected by H_2S in Gas



Copper Aftercooler Core Corroded by H_2S Mixed With Condensed Water

Contaminants And Their Impact

- **Hydrogen Sulfide, H_2S**
  - Forms sulfuric acid
    - Corrodes metals containing copper

- **Halogenated Hydrocarbons**
  - CFCs break down during combustion, releasing:
    - **Chlorine ➔ hyrdrochloric acid**
    - **Fluorine ➔ hydrofluoric acid**
      - » Both acids accelerates wear of piston rings, cylinder liner, exhaust valves, and valve guides

Contaminants And Their Impact

- **Abrasive- Silicon**
  - 2nd most common element on earth… common in landfills
    - Causes abrasive wear
  - Typically caught by fuel filters
  - Man-made crystals below 1 micron can be entrained in gas
    - Not typically a problem with normal fuel conditioning

Contaminants And Their Impact

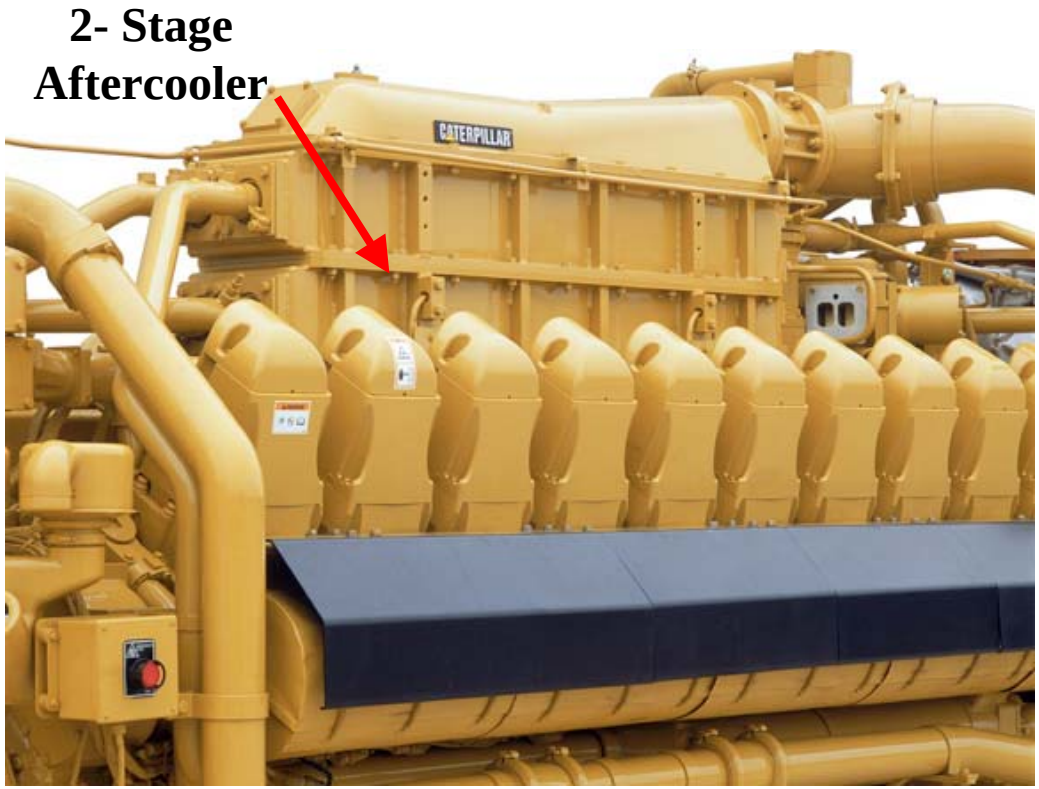
- **Siloxanes**
  - Common in cosmetics, cleaners, lubricants
  - Can be found in biogas and water vapor in the gas
    - Leads to deposits in combustion chamber and exhaust
    - Build-up in the cylinder increases the compression ratio
    - Build-up on valves can cause guttering, abrasive wear

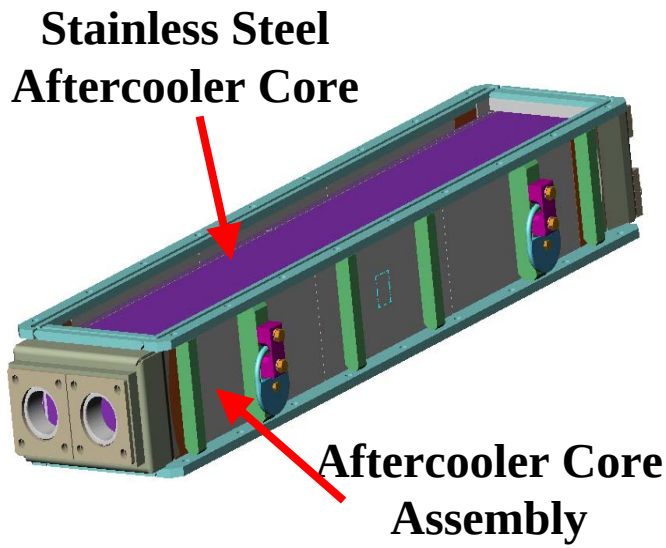
Optimized Landfill Gas Engine Designs

- Engine systems for landfill applications are modified to resist the effects of fuel contaminants...examples
  - Corrosion resistant materials
  - Elevated jacket water temperatures
  - Crankcase evacuation ventilation system

Landfill Gas Engine Designs

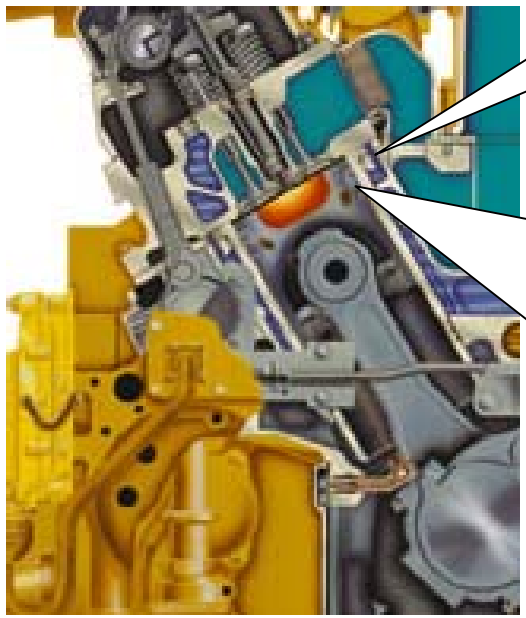
- Material changes
  - Bright metals removed in susceptible areas
  - Stainless steel aftercooler core





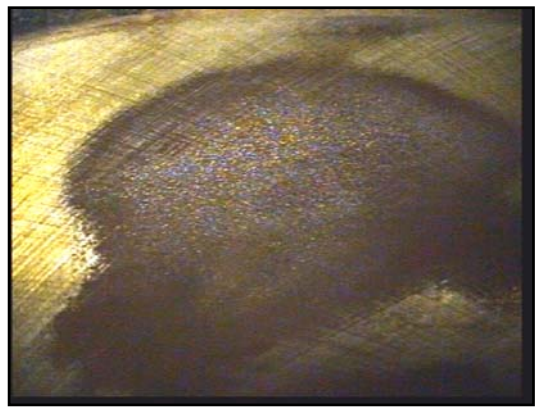
Landfill Gas Engine Designs

- Elevated Jacket Water Temperature
  - Protects internal engine components from corrosion and from condensation of sulfuric and other acids



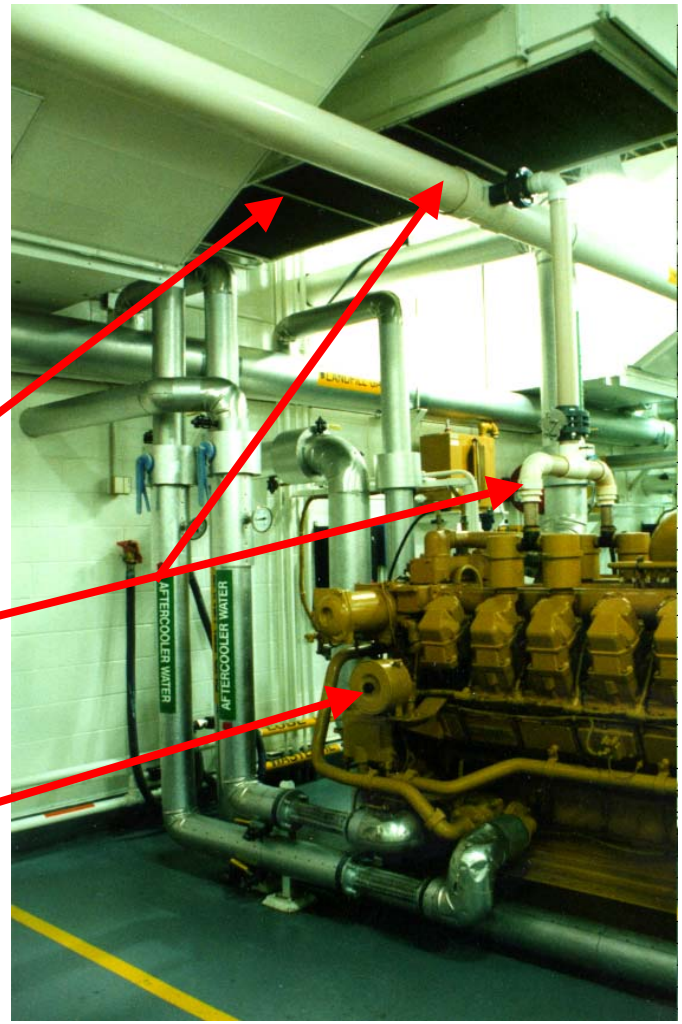
Piston Cooling Shelf: High water volume for proper top of liner cooling

Liner corrosion from high volume of water at standard temperature

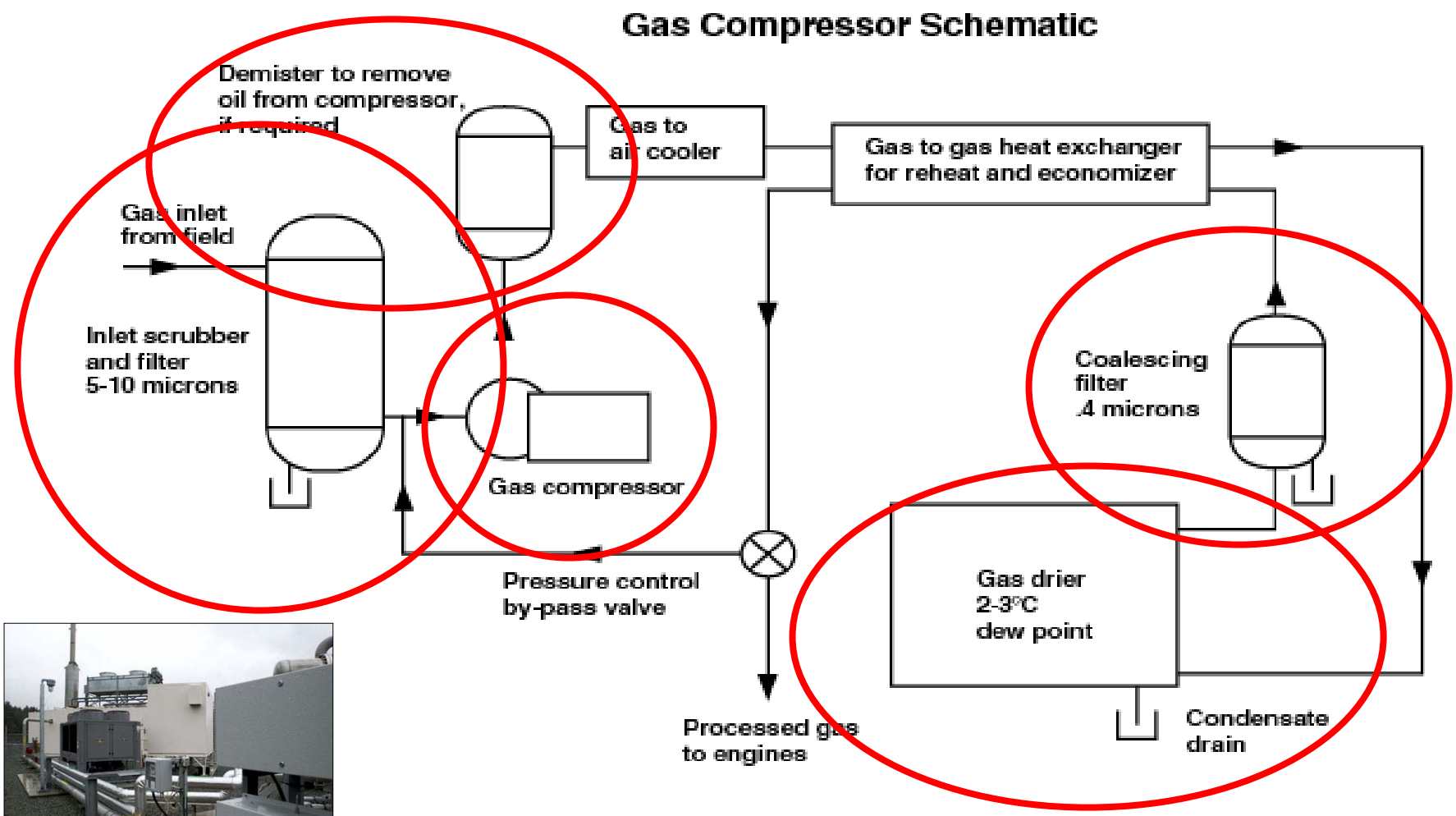


Landfill Gas Engine Designs

- Crankcase Ventilation
  - With warmed intake air to prevent condensation and corrosion from blow-by gasses with fuel borne contaminants
  - Extends oil life



Fuel Conditioning



Contaminants Guideline For Gensets

- All manufacturers have recommended guidelines
  - Stay inside the guidelines for best engine maintenance costs
  - Contaminant levels above recommended levels will cause increased maintenance costs and shorter life to overhaul.

- Reduced component life and increased engine maintenance may be a better financial alternative than extensive fuel treatment.

Comparing the Options

- Get a complete **fuel analysis**
- **Evaluate fuel treatment options** and costs
- **Develop engine maintenance costs** in $/kW-hr
  - With treated fuel
  - Without treated fuel
    - Remember that the amount and types of contaminants will influence service intervals
  - Talk to your engine supplier about long-term maintenance contracts
- **Compare and evaluate options** based on local conditions and available expertise

Conclusions 结论

- Because of site fuel variations, there is no one “right answer” that fits all cases.

  由于现场填埋气的多样性，没有一种所谓唯一“正确答案”适应所有应用场合。

- Review the costs and benefits to fuel pre-treatment.

  审核各种填埋气预处理方案所带来的好处及相应成本。

- The best “right answer” for any one project may be a combination of treatment and optimized engine maintenance practices.

  对于任何项目而言，最好的“正确答案”可能是将填埋气预处理与发动机的优化保养程序相结合。