OTD Operations Technology Development

Assessment of Acceptable Siloxane Concentrations in Biomethane

Biomethane from various waste products could provide consumers with a significant source of "green" renewable energy. For this project, a study was conducted into siloxane – one of the potential constituents in biomethane – to assess its influence on health, the environment, and gas-fired appliances.

Project Description

Local gas distribution companies are increasingly asked to purchase and take delivery (interchange) of fully processed biomethane from the anaerobic digestion of waste into existing lines for general distribution. However, the original raw biogas can contain many different trace constituents. While methods being developed can upgrade raw biogas to high-Btu biomethane, this fully processed biomethane is not often accepted into existing pipeline systems.

One constituent of concern is siloxane, a man-made organic compound that contains silicon, oxygen, and methyl groups. Due to the increase in silicon-containing personal hygiene, healthcare, and industrial products, the presence of siloxane in waste streams has increased. As the silicon-containing waste stream/biomass is digested, smaller weight siloxane compounds volatilize and become entrained in the biogas. When this gas is combusted, silicon dioxide is formed. Over time, the silicon dioxide builds up and can cause damage. Certain concentrations in biomethane may lead to environmental health and safety concerns; however, the potential toxicity and risk of siloxanes is being debated.

To address various siloxane issues, in Phase 1 of this project (now completed) an extensive study was conducted to provide documentation to support guidance in the area of acceptable levels of siloxane in biomethane. The objective of Phase 2 (also completed) was to perform laboratory testing on vented and unvented gas-fired appliances to evaluate equipment tolerance and potential indoor air concerns with siloxane, respectively, in order to determine adequate concentrations for safe acceptance of biogas in distributions systems. Data collected from laboratory testing will be used to develop a preliminary risk assessment model.

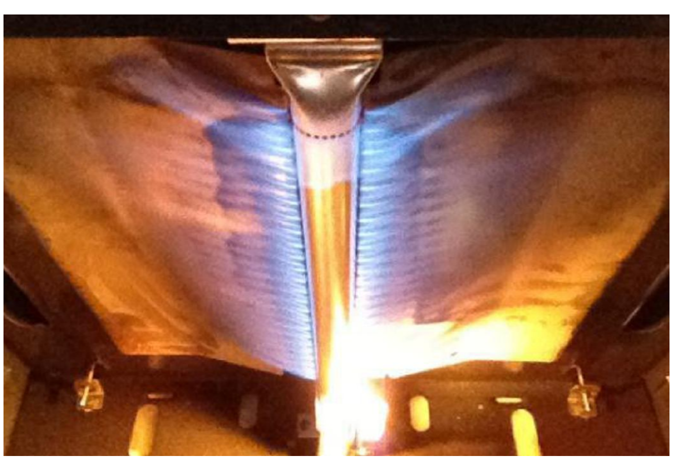
Deliverables

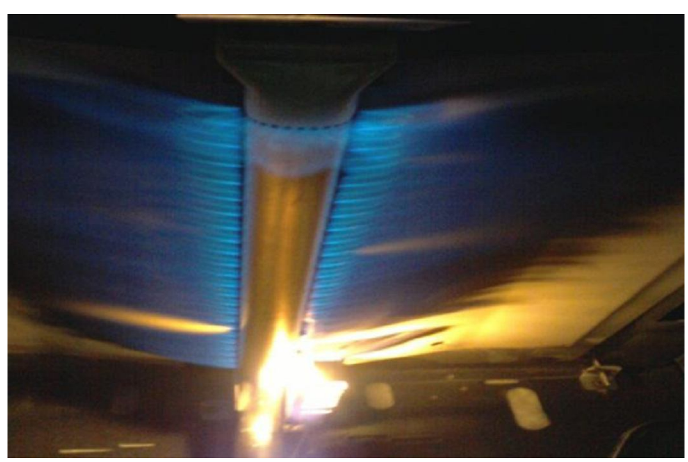
The deliverable for Phase 1 of this project was a technical summary with data to provide guidance for natural gas companies and biogas project developers in their efforts to introduce renewable gas into natural gas pipelines.

Phase 2 deliverables include a preliminary risk assessment that may be used by utilities to analyze their risks with respect to their unique requirements. Depending on results from Phase 2, additional laboratory testing may be performed in Phase 3 to allow for a comprehensive risk assessment.

Benefits

Results from this project could provide a variety of significant benefits, including guidance to utilities on assessing the risks associated with siloxane concentrations for biomethane interchange.





Images of the water-heater flame were taken weekly to document any visual changes. At left is the baseline flame image.

Importantly, the potential health effects of siloxane concentrations will be viewed with the benefit of scientific information.

Technical Concept & Approach

Research tasks include:

- A Review of Existing Data
- Manufacturer Interviews and Data Collection
- Laboratory Testing on Vented and Unvented Gas Appliances (water heater and oven, respectively)
- Development of a Preliminary Risk Assessment.

Results

In 2010, a report was issued that summarizes the initial research of Phase 1 and formed the foundation for field studies. The results of Phase 2 are presented in a report issued in October 2013.

In 2012, testing began with a water heater for the vented appliance and an oven for the unvented appliance with siloxane spiking of the fuel gas. The units operated Monday through Friday for eight hours per day. During the testing period, samples of the fuel gases were periodically analyzed to monitor siloxane concentrations. Flue gas samples were also analyzed to monitor changes in component levels, particularly carbon monoxide and carbon dioxide. Air samples were taken above the oven and monitored for particulates, and coupons were placed inside the oven to monitor surface accumulation.

The water-valve timer was set to a period of 40 minutes with a 10% on time, thus resulting in a typical water draw for testing and still allowing enough time for the water tank temperature to return to the set point before cycling the burner again.

Periodic analysis of the flue gas showed no significant changes to carbon dioxide and carbon monoxide during the length of testing. Internal inspection of the water heater showed significant accumulation of silica deposits on all surfaces in contact with the flue gas, and a large deposit of material on top of the burner. Analysis of this material showed it to contain a mixture of silica and iron, most likely due to rust.

Operation of the unvented oven showed no effects due to siloxanes until the oven's ignitor coil began to sporadically fail as the accumulation of silica deposits on the ignitor coil increased its resistance to a point where the circuit struggled to reach the current threshold for opening the gas valve.

Laboratory testing.

Sampling of the oven flue gas above the range did not produce any observable particulates above a detection limit of 0.07 mg/m3. A significant amount of deposits was observed on all surfaces of the oven and flue vent, and scrapings of these deposits confirmed that they were amorphous silicon dioxide.

Data collected during the testing period was used to create a preliminary risk assessment model, which showed the exposure risk to be minimal, but there is a potential impact risk on increased cost in appliance maintenance and/or accelerated replacement due to silicon dioxide deposits.

Status

The research team is developing a risk assessment that describes and evaluates the likelihood of adverse effects, and includes a hazard assessment, exposure and impact assessment, and risk characterization.

For more information:

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