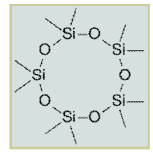
Assessment of Acceptable Siloxane Concentrations in Biomethane – Phase 1

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 heath, the environment, and gas-fired appliances.



Project Description

Local gas distribution companies (LDCs) are increasingly asked to purchase and take delivery of fully processed biomethane from the anaerobic digestion of waste for co-mingling into existing lines for general distribution. The original raw biogas can contain many different trace constituents. A separate project is under way to evaluate the effectiveness of cleanup technologies to upgrade raw biogas to high-BTU biomethane. However, 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.

Currently, there is no tariff for the concentration of siloxane in gas (natural gas and biomethane), although some engine manufacturers have their own specific limits.

Evidence of siloxanes in biomethane is found in the form of a white powder in the hot sections of gas turbine components, as a light coating on various types of heat exchangers, in deposits on combustion surfaces in reciprocating engines, and as a light coating on post-combustion catalysts.

To address various siloxane issues, an extensive study was conducted to provide documentation (literature, industry standards, laboratory testing, etc.) to support guidance in the area of acceptable levels of siloxane in biomethane.

Deliverable

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. As the project moves forward with Phase 2, the final deliverable will be a guidance document that may be used by utilities to analyze their risks with respect to their unique requirements.

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.

Proposing a range of appropriate siloxane concentrations in biomethane will also help reduce risk to customer equipment. In addition, liability may be avoided if more accurate information on the impacts of siloxane concentrations is known.

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

Technical Concept & Approach

This project focused specifically on collecting and documenting readily available information in the area of siloxane tolerance (focusing on major commercial/ residential end-use applications and specialty equipment).

Research tasks included:

- **A Review of Existing Data**

  Data sources were from the United States, Canada, and Europe. Information on known health-risk levels of siloxane were obtained from leading governmental agencies. Researchers also reviewed information pertaining to end-use equipment, instrumentation for on-site siloxane measurement, and equipment that potentially removes siloxane from waste streams.

- **Manufacturer Interviews and Data Collection**

  Leading manufacturers of end-use equipment were interviewed and data on specifications pertaining to burner configurations were compiled. Experts in the field were consulted and the most current data was used for the purposes of equipment comparison.

Results

The following are some of the most significant findings:

- The concentration and types of siloxane differ from each landfill and digester plant. It is very difficult to trend siloxane types and concentrations because a spike of siloxane will deviate from average concentrations. Typically, closed landfills contain relatively low levels of siloxane.

  One main end-use issue that may arise from the introduction of siloxane from biomethane intermingled with the natural gas supply is a buildup of silica dust on burners or flame sensors. Theoretical values for the amount of deposits were calculated, assuming all siloxane converted into silica dust and deposited onto the flame sensor. Using a matrix of different flame-sensor lengths and potential deposit thicknesses, the number of days to failure mode was estimated. Using the average total siloxane concentration from the literature search (and assuming that the failure mode comprises a 0.10mm deposit with a one-inch flame sensor) failure can occur in 21 days. However if only 5% of the silica is deposited on the flame sensor, failure would occur in 427 days. Given the many uncertainties, laboratory experiments using a number of flame sensor and burner configurations are needed to obtain more accurate data.

- The need for real-time monitoring equipment has increased due to the waste disposal of siloxane in landfills and sanitary sewers.

- Since there exists no standard for the collection and analysis of siloxanes, inconsistencies in the types of siloxane analyzed arise from laboratory to laboratory. In addition, there exists no standard for the frequency at which samples should be taken.

- Many types of siloxane removal techniques are commercially available. Most removal methods are by physical adsorption.

- Respirable silica is one form of silica generated during the combustion of siloxane. The amount of siloxane found in biomethane was used to calculate the amount of silica that may enter the home from unvented appliances, such as gas-fired ranges. It is uncertain whether the amount of silica dust that enters and accumulates in the home may reach levels of concern.

- There is some debate on whether the presence of trace constituents in a gas would have an impact on odor fade.

- Unlike with residential appliances, the affect of siloxane in biogas is well understood pertaining to energy-generating equipment. Manufacturers have set siloxane limits on their equipment since silica buildup on various parts of equipment requires additional and more frequent maintenance. There exists no information regarding siloxane buildup in residential applications.

- Siloxane may enter the indoor air environment due to the delay from the ignition. However, the amount entering the home would be in very trace amounts.

Status

A Final Report detailing findings in text and tables was issued in August 2010.

Investigators recommended that further laboratory testing be conducted to explore the deposition of silica on appliances; the morphology of siloxane from typical concentrations and types in biomethane to evaluate indoor-air quality; and flow rates and velocities of gas flow.

An additional phase of this project would involve testing to more accurately determine the concentrations of siloxane acceptable in cleaned biomethane.

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