

Testing of Residential Appliances for Impact of Siloxanes

Description: Practical testing to evaluate effect of Siloxanes on residential appliances' performance

Status: Appliance testing produced initial results; additional testing ongoing.

BENEFITS

This project aims to address the ongoing dialogue on the technical limits of siloxanes in Renewable Natural Gas (RNG). Assessment of siloxane impacts on sensitive natural gas end-use equipment will help to specify technically-sound limits. The largest impediment for translating results obtained from available literature is that a majority of in-use appliances are designed differently from those that have been previously studied. Additional testing will help us reduce the uncertainties by providing scientific data to support siloxane limit recommendations.

Considering growing demand for RNG production and injection into distribution infrastructure in North America, the testing should help both producers and developers to determine the optimum upgrading and measurement system for siloxanes in biomethane.

BACKGROUND

To reduce carbon emissions and to move towards a more sustainable energy supply, there is an increasing trend of using RNG in the United States and Canada. Depending on the source, RNG can contain compounds that are not present in traditionally distributed natural gas such as siloxanes (See Figure 1). Siloxanes are man-made organosilicon compounds found in a wide range of consumer products such as detergents, shampoos, cosmetics, paper coatings and textiles. These products can find their way to biogas feedstock such as wastewater sludge, landfills etc.

NYSEARCH conducted two studies, one of which was a Risk assessment of the effects of Siloxanes

on residential gas appliances and gas engines by DNV-GL. It was based on an experimental evaluation of siloxane impacts on multiple residential appliances that was recently conducted in Europe. The study concluded that there were a few major differences in the appliances between Europe and North America, mainly the absence of an air-fuel ratio and controller, presence of thermocouples in appliance and different heat exchanger configurations (and materials). These differences can have a significant impact on acceptable siloxane limits for these appliances. Hence, it was recommended that an inventory of appliances be taken in NYSEARCH member areas and a measurement program be developed for tests on these appliances to identify and quantify their failure modes.

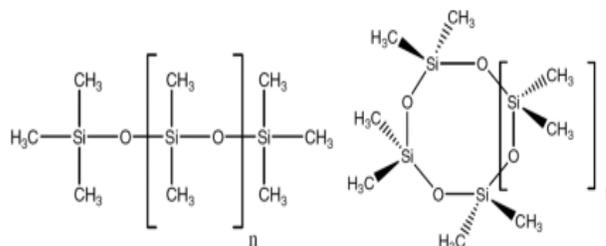


Figure 1: Repeating structural units for Linear (Left) and Cyclic (Right) Siloxanes

TECHNICAL APPROACH

The objective of the project is to determine the maximum concentration of silicon-containing molecules (See Fig. 1) in RNG that will preclude significant safety, reliability, performance, and maintenance impacts for US and Canadian residential appliances. The first step was to develop a Test Plan. Published results were

reviewed from the residential appliance tests in which the impacts of siloxanes were evaluated including the (2) NYSEARCH studies completed in 2019. Discussions were held with research organizations that have conducted these tests (e.g., DNV, University of Southern California) focusing on test protocol, specialized laboratory equipment, and siloxane impacts on appliances. Of significant interest were appliance characteristics that result in sensitivity to silica deposits (e.g., heat exchanger geometry, heat exchanger materials, and flame sensor position) and the equipment utilized by these organizations to accurately blend low concentrations of siloxanes into natural gas.

The next step was to carry out the appliance testing. Testing is taking place in two rounds. In Round 1, about (8) appliances were setup in Primaira's laboratory (See Fig. 2), located in Woburn MA. Gas, electrical, water, and venting connections were secured and the siloxane blending system was integrated into the gas piping. The siloxane system consists of several vessels containing liquid siloxanes (e.g., D5).



Figure 2: Test Setup at Primaira Lab

Pressure, temperature, and flow rate controls enable accurate setting of the concentration of siloxane in natural gas. The siloxane dispersion system was rented from DNV-GL in the UK. Based on the Round 1 results, appliances that are found to be sensitive to siloxane impacts, are to be selected for testing at a lower siloxane concentration, in Round 2. New or replacement appliances are also being acquired, and baseline performance testing is being conducted.

At the conclusion of testing in Rounds 1 and 2, the results for each appliance are also being analyzed to estimate the maximum siloxane concentration that would prevent the observed failure mode from occurring over that appliance's expected service life. By combining results for all the appliances tested, we will determine the maximum siloxane concentration that is expected to be acceptable for the US and Canadian residential appliance population.

PROGRAM STATUS

Test planning has been completed. Sensitive appliances were selected based on Expert advice and input from NYSEARCH project sponsor(s). Baseline appliance testing was carried out to ensure the setup for the siloxane delivery system works well. Round 1 testing for high siloxane concentration (~12 mg/Si m³) has been completed and failure modes are being analyzed. The results have been shared with the project SME's and a list of appliances have been proposed for Round 2 (low Si concentration) testing. At the end of Round two testing, we will have two data points to extrapolate the results for the lifetime per gas usage of the appliances.

For more information contact:
admin@NYSEARCH.org