Biomethane Impurities (RP3.2-09)

This project aimed to establish regulatory quality requirements for biomethane injection into Australian gas networks. A clear collection of biomethane quality standards can provide pipeline operators, end-users and biomethane project developers with a clear understanding of quality obligations, alongside operational and cost responsibilities. The overall project purpose is to improve industry confidence in biomethane injection, leading to increased market participation.

The study provided a detailed list of contaminants of concern with quantified allowable limits based on a comprehensive literature review. It further presented methodologies for biomethane injection pathways in compliance with Australian Standard AS 4564 and state-by-state legislative requirements.

Identified parameters were divided into two classifications; those that already possessed existing limit values in AS 4564 (e.g., Wobbe Index, oxygen content) and those that did not (e.g., ammonia, siloxanes).

The second class of parameters were assessed to provide Australian decision makers with information to determine the appropriate limit values for biomethane quality for Australian pipelines. To assist with this process, the literature was reviewed for quantitative concentration values in biogas / biomethane, along with existing regulatory information. This information was combined with analysis of the integrity and health-based detrimental effects associated with each parameter, and the effectiveness of biomethane upgrading methods in removing said parameter, to inform Australian decision makers.

Examination of AS 4564 found three potential avenues for improving the viability of biomethane production, via the relaxation of the minimum and maximum Wobbe Index and oxygen / total inerts concentrations, respectively. These initiatives are based on similar efforts found in other biomethane producing jurisdictions examined, which could be emulated for Australian biomethane production. An industry workshop was held online on 20th July 2021 which was attended by 22 stakeholders from 13 industry / regulatory organisations. The workshop concluded:

I. Oxygen was identified as one of the most important impurities affecting project economics.

II. There was an emphasis on an "enable all" approach for providing guidance on how developers may comply with Australian biomethane quality requirements

III. There was an experience-based consensus established that higher O_2 limits (up to 1 mol %) are unlikely to lead to flame abnormalities in Type A appliances, however a testing program utilising higher O_2 concentrations was still recommended. Note that this testing program was included within Project RP1.4-07 (Biomethane injection into the gas network: impact of impurities on the performance of end-use appliances).

Computational Fluid Dynamics (CFD) simulations of biomethane and natural gas mixing showed that the biomethane-blended natural gas becomes close to fully mixed within 20 m from the injection point, with less than 5% change in the concentrations of the gas constituents compared to the average. This means that if the average composition of the mixture is within AS 4564 limits, this should be delivered to end-users further away. Consequently, these concentrations can be estimated using mass balance calculations without requiring CFD simulations.

Modelling was used to provide insight into the corrosion of natural gas pipelines after injecting biomethane with oxygen (O_2) concentrations greater than the AS 4564 allowable limit, i.e. 0.2 mol%. Corrosion rate calculations were performed by two approaches: a theoretical method simulated by FREECORP software, and an empirical model developed from experimental data. Key conclusions from the corrosion modelling were:

- The mechanism of corrosion in natural gas pipelines shows that O_2-induced corrosion requires liquid water to take place.
- If such free water is present, the increase in corrosion rate is approximately linearly proportional to the increase in oxygen partial pressure. This means doubling the oxygen concentration would likely double the internal corrosion rate in any existing asset.
- The corrosion rate increases with CO_2 partial pressure but the increase is less pronounced than that of O_2.
- The corrosion rate increases with the velocity of the aqueous phase, which may move more slowly than the bulk gas flow.
- The effect of temperature on the corrosion rate is also linear and stronger than CO_2 partial pressure.
- the most vulnerable assets are those operating under high total gas pressures and with a possibility of free water to be present.

RECOMMENDATION

Based on an analysis of international practice, it was recommended that a new NOTE be added to Table 4.1 in AS4564 as follows:

> **NOTE 6 Higher oxygen concentrations (up to 3%) may be permissible if appropriate validation of downstream assets and infrastructure permits. In such cases, additional risk mitigation actions may be required and should be discussed with the relevant regulatory authority. See Appendix A3.4.**

With Appendix A3.4 expanded to read:

> **Internal corrosion of pipeline infrastructure is exacerbated by high partial pressures of oxygen. Such corrosion will occur if water is present as a free liquid, adsorbed to hygroscopic salt deposits or absorbed in liquid glycol carried over from dehydration units. Corrosion increases with temperature and in the presence of acidic gases (carbon dioxide and hydrogen sulfide).**

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