Investigation of Methane Emissions from Flares in a Turbulent Crosswind

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Abstract

Despite evidence that flares subjected to crosswinds can undergo fuel stripping mechanisms that reduce efficiency and lead to emissions of unburned fuel, the majority of published flare experiments have not considered the impact of a turbulent crosswind and are therefore questionably relevant. Flare gases may contain a high percentage of methane, a short-lived climate pollutant with 20- and 100- year global warming potentials of 86 and 34, respectively. Thus, a better understanding of the emissions of flares rich in methane is crucial from both an environmental and regulatory perspective. Using a large closed-loop wind tunnel (5 by 4 m test section), experiments were performed to quantify carbon conversion efficiency and species emission rates of flares burning methane-rich gases subjected to turbulent crosswind. Experimental conditions considered influences of wind speed and atmospheric turbulence levels, as well as flare flow rates, diameters, and flare gas composition. Flare efficiency and methane emissions were accurately calculated through a novel method based on solving the unsteady mass balance within the wind tunnel to relate measured accumulation rates in the wind tunnel to flare emission rates, while accounting for infiltration, exfiltration, and potential for re-entrainment of emitted species in the tunnel air to the flame. Results are presented within precisely quantified uncertainty limits and demonstrate that turbulent (gusting) crosswinds play an important role in increasing flare emissions and methane slip. These new data have an number of important implications in the context of increased flared volumes in the United States and globally and the quest to reduce oil and gas sector methane emissions.

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