CHAPTER

5

CFD-BASED INSIGHTS INTO SUSTAINABLE GAS PIPELINE OPERATIONS

Muhammad Nurhaleem Mohd. Yusoff, Zulkifli Abdul Majid, Norhana Mohamed Rashid, and Mohd Dinie Muhaimin Samsudin

5.1 INTRODUCTION

The discovery of natural gas by ESSO in Terengganu, Malaysia, in the early 1970s marked the beginning of a rapidly growing natural gas market (Fox et al., 2011). Since then, significant advancements have been made in various aspects of the natural gas industry, including production, transportation—whether by tank or pipeline—and the process of injecting odorants into the gas. The continuous enhancement of natural gas-related technologies remains crucial as demand for this fuel continues to rise, solidifying its role as one of the primary energy sources.

Natural gas transportation is fundamentally driven by pressure differences, where gas flows from higher-pressure transmission lines to lower-pressure distribution systems. At this transition point, the gas typically passes through a city gate, a key facility that performs several essential functions (Folga, 2007):

(1) Reducing gas pressure from transmission levels to an acceptable range for distribution.

(2) Facilitating the odourisation process by injecting a distinctive sour-scented odorant, enabling consumers to detect even small gas leaks.
(3) Measuring the gas flow rate to determine the volume received by the facility.

The odourisation process is especially important because natural gas is naturally colourless and odourless. Odourisation ensures that leaks can be detected well before the gas reaches hazardous concentrations, thereby enhancing safety for both industrial and public consumers. Given the widespread use of natural gas and the potential risks associated with undetected leaks, maintaining proper odorant levels is a fundamental requirement in natural gas delivery systems.

This foundational understanding of natural gas transportation and odourisation provides the context for the subsequent discussion on safety risks, regulatory requirements, odour fade phenomena, and the application of computational fluid dynamics (CFD) to analyse odorant losses within pipeline networks.

5.1.1 Safety Risks Associated with Natural Gas Leaks

As a combustible hydrocarbon, natural gas poses significant risks, particularly in industrial settings where undetected leaks can lead to catastrophic consequences. One such incident occurred at Hampshire Park Condominium in May 2011, where an explosion resulted from an undetected natural gas leak (Chiew, 2011). To mitigate such risks, legislation mandates the odorisation of natural gas before it reaches the public. This ensures that leaks can be detected well before the gas reaches its flammability threshold. The standard requirement is that consumers should be able to detect the presence of gas by smell when its concentration in the air reaches one percent. Given that the lower flammability limit of natural gas is approximately five percent, this one percent threshold provides a safety margin equivalent to one-fifth of the lower flammability limit (Speight, 2019).

5.1.2 Odorant Selection and Injection Systems

According to Speight (2019), although odorants contain sulphur compounds and may have some level of toxicity, this is not a concern because only small quantities are present in natural gas. The odorant supplied along with the natural gas to end consumers is considered non-toxic due to its extremely low concentration. The importance of injecting a strong-scented odorant into the otherwise colourless and odorises natural gas is evident, as it allows leaks to be detected before a fire or explosion can occur. A crucial step in the odorisation process is selecting a suitable odorizing system. The choice of an odorizing system depends on several factors, including natural gas flow rates, pressures, gas quality, pipeline condition, and odorant type (Tenkrat et al., 2010). From a technical perspective, odorises are typically classified into two main categories:

(1) Chemical Vapourisation Odorizes–These systems rely on the evaporation of liquid odorant into the natural gas stream.
(2) Chemical Injection Odorises–These systems inject precise amounts of odorant directly into the gas flow.

5.1.3 Monitoring and Regulatory Requirements

Accurately measuring odorant levels in natural gas pipelines is essential. If the odorant concentration falls below the legally required level, the gas company not only violates regulations but also endangers its customers. Conversely, if the odorant level is too high, it can cause adverse effects such as headaches and nausea. Several techniques are used to determine the concentration of odorants in natural gas. One common method involves measuring the sulphur content in the odorant using the SEWERIN EX-TEC OD 4 device (Pusat Teknologi Gas [GASTEG], 2013). If the concentration of mercaptan exceeds the allowable limit, engineers initiate a purging procedure through a sampling port while continuously monitoring the natural gas concentration in the surrounding air with a portable gas detector.