

CHAPTER

6

PORTABLE GAS MONITORING FOR STRUCTURE SAFETY

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6.1 INTRODUCTION

Gas is one of the fundamental states of matter, plays a vital role in the modern world. It coexists with solids, liquids, and plasma, each having distinct physical properties. Gases are unique due to their ability to expand and fill any container, taking its shape while maintaining uniform pressure. This property allows gas to be compressed, stored, and transported easily, making it a versatile resource in many sectors.

In industrial applications, gas is indispensable. It is used in manufacturing, heating, and energy generation. Natural gas, for instance, is a cleaner-burning fossil fuel used for heating homes and powering factories. In the welding industry, gases like acetylene and butane are crucial for creating the high temperatures needed to fuse metals. Their use spans across numerous industries, including construction, automotive, aerospace, and shipbuilding, where precision, safety, and efficiency are critical.

Despite its usefulness, gas also poses inherent dangers. Leaks in transportation or storage systems can lead to fires, explosions, and toxic exposure. A small spark near a leak could lead to catastrophic loss of life, equipment, and environmental damage. Historical incidents, such as the

2010 San Bruno pipeline explosion in California (Cheng et al., 2024), underscore the severity of such hazards. These events emphasise the critical need for robust gas leak detection systems that are efficient, accessible, and responsive.

This chapter discuss into the conceptualisation and realisation of a portable gas leakage detection system aimed at improving industrial safety. The proposed device focuses on early detection and user alerting, particularly in environments where gas is extensively used and the risk of leakage is high.

6.2 UNDERSTANDING GAS LEAKAGE AND DETECTION METHODS

Gas leakage poses significant risks in industrial settings and must be detected promptly to prevent hazards such as fires or explosions (Tondini & Franssen, 2017). Detection methods include non-technical approaches using human senses, acoustic methods using sound sensors, and analytical techniques like mass or volume balance as shown in Figure 6.1. Sensor-based systems have become the most reliable due to their real-time, automated capabilities and adaptability in various environments. Combining these methods increases the effectiveness and safety of leak detection systems.

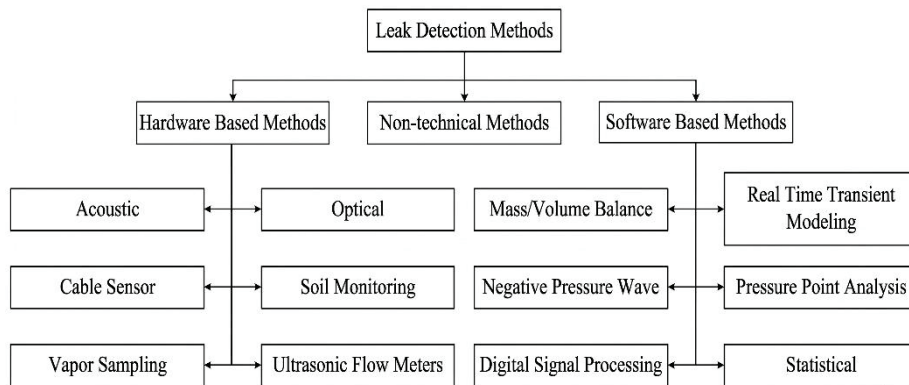


Figure 6.1 Gas leak detection based on specialised nature

6.2.1 Nature of Gas Explosions

To comprehend the necessity of gas leak detection, it is essential to understand the dynamics of gas explosions. An explosion occurs when gas accumulates in an enclosed or semi-enclosed space and mixes with air to form a combustible mixture. When this mixture is ignited by a spark or heat source, it combusts rapidly, releasing massive energy in the form of heat and pressure.

There are different types of explosions based on the environment and the nature of the gas. In an open area, the gas disperses quickly, often preventing sufficient concentration to cause an explosion unless the leak is substantial. In enclosed areas such as buildings or underground pipelines, leaked gas cannot escape easily, leading to higher concentrations that pose greater risks.

The severity of an explosion depends on multiple variables: gas type, volume, concentration, duration of accumulation, and ignition source. Butane, for example, is highly flammable, and even a small leak can pose severe risks if undetected. Thus, monitoring gas levels in industrial environments is vital not only for operational efficiency but also for the protection of life and property.

In this research, safety is the highest priority. Based on Figure 6.2, the gas selected for demonstration must have a low lower explosive limit (LEL). LEL is defined as the lowest concentration of a gas in air that is capable of producing a flash of fire in the presence of an ignition source. Therefore, butane gas was chosen because it has a low LEL of 1.8%. Moreover, butane is readily available in the market, making it practical for testing purposes. Figure 6.3 shows an example of the butane gas used in this research.

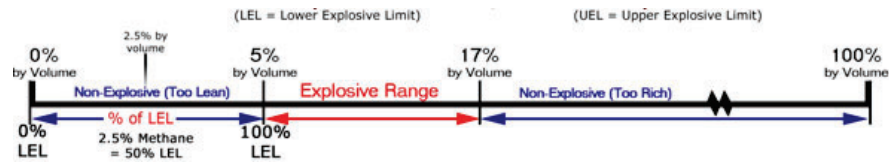


Figure 6.2 The percentage of gas concentration for lower explosive limit and upper explosive limit