Incident Summary #II-1216438-2021 (#22636) (FINAL)

SUPPORTING INFORMATION	Incident Date		June 27, 2021
	Location		Vancouver
	Regulated industry sector		Gas - Natural gas system
	Impact – Injury	Qty injuries	0
		Injury description	N/A
		Injury rating	None
	Impact – Damage	Damage description	Release of a significant quantity of compressed natural gas (CNG) into multiple parkade levels and an adjacent building's HVAC system
		Damage rating	Moderate
	Incident rating		Moderate
	Incident overview		A pressurized bank of compressed natural gas (CNG) cylinders were subject to high ambient temperature during a heat wave, causing an increase in pressure and subsequent relief valve discharge of natural gas into the atmosphere and an adjacent building's HVAC system.
INVESTIGATION CONCLUSIONS	Site, system and components		The site in question is an abandoned CNG filling station that was used to fill CNG vehicles. The station consists of a natural gas supply provided by the utility that is compressed to a high pressure via a 3-stage compression system. The gas is compressed into three storage banks, low, medium, and high. Each bank consists of two cylinders connected to a common relief valve. Each cylinder is approximately 20 feet long and 16 inch in diameter (Image 2 and 7). The cylinders have a maximum allowable pressure of 5000 PSI The as-found pressure in the cylinders (measured via pressure gauge) was as follows: Storage bank 1 - Empty Storage bank 2 - 2200 PSI Storage bank 3 - 3600 PSI Each two-cylinder bank is connected to a single relief valve that is set to relieve at a pressure of 4400PSI (Image 2 and 3). The relief valve protects the cylinders from excessive pressure. The relief valves are connected to a steel vent pipe that releases the natural gas to a location approximately 20 feet above the cylinder bank (Image 5). The intent of venting to this location is to direct the natural gas away from sources of ignition or building openings.
	Failure scenario(s)		The CNG station was decommissioned in 2015. The electrical and gas supply to the station was removed and the compressors and cooling system were decommissioned. The CNG cylinders were disconnected from the piping system but still connected to the relief valves. 4 of the 6 cylinders were not emptied during the decommissioning.

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	A high-rise tower was recently constructed next to the cylinder building and relief valve discharge (the distance between the rear cylinder building and high-rise tower is approximately 3 feet). As a result, the relief valve discharge pipes terminated near the adjacent building's HVAC air intake (Image 4 and 6). On the week leading up to the natural gas release the area was experiencing a record high heatwave with temperatures above 40 degrees Celsius. Stored outdoors, the CNG cylinders were subject to high ambient temperature and radiant heat from the sun. This increase in temperature caused an increase in gas pressure, most likely exceeding the relief valve setting of 4400 PSI. The relief valve discharged near the adjacent building, releasing a large volume of gas that was drawn into the building's HVAC air intake. Gas was found on parkade levels P1,P2 and P3.
Facts and evidence	-On June 27 the Fire Department responded to reports of an explosion from a nearby tenant. It should be noted that the reported explosion was not actually an explosion, but the sound of the relief device operating as intended to maintain safe pressures within the vessel. -The first responders found a heavy smell of gas around the cylinders as well as in the parkade of an adjacent building. -The likely cause of the reported explosion was the triggering of the relief valve(s) serving the CNG tanks which may be extremely loud when relieving at a pressure of 4400 PSI. -Subsequent investigation found that two of the cylinder banks (4 cylinders) were under pressure with natural gas. The first bank was found to have a pressure of 3600 PSI and the second, a pressure of 2200 PSI. The third bank of cylinders was found to be empty. -The large amount of natural gas detected in proximity to the cylinders by the fire department suggest the cylinders were the source of the gas release. -The proximity of the relief valve vent lines to the adjacent building indicates they were likely the source of gas that infiltrated the parkade. -The reported explosion coincides with the anticipated sound of a high-pressure relief valve discharge. -Utility gas supply had been removed from the site, making the CNG cylinders the only potential source of gas -4 of the 6 cylinders were found to be under high gas pressure. -The high ambient temperatures correlate with an increase of gas pressure in the cylinders. (Gay-Lussac's Law states that the pressure of a given mass of gas varies directly with the temperature of the gas, when the volume is kept constant) -The dilapidated site conditions suggest that the cylinders and associated relief valves had not been inspected or serviced for an extended period

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Causes and contributing factors	It is likely that persistent, high ambient temperatures contributed to an increase in pressure inside the CNG cylinders, exceeding the relief valve trip point. The relief valves relieved under an overpressure condition and released a large quantity of natural gas into the atmosphere and adjacent building. Record setting high seasonal temperatures exposed the cylinders to pressures greater than the relief valve setting. The failure to properly decommission the site resulted in a high hazard condition

Image 1 - Site overview showing the location of the CNG cylinders

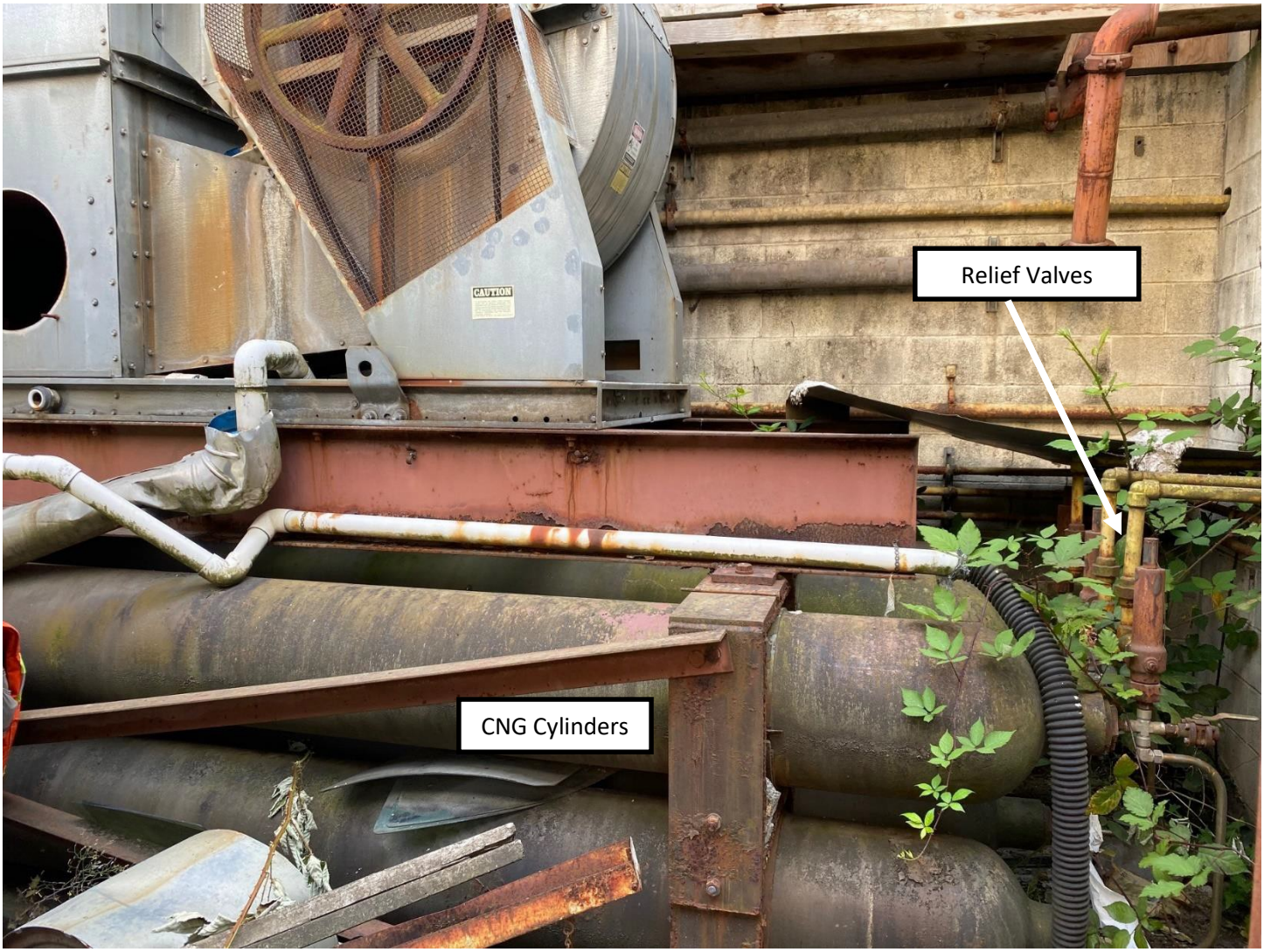

Image 2 - CNG Cylinders. Two cylinders are connected to a common relief valve

Image 3 - Relief Valve set at 4400 PSI

Image 4 – location of adjacent building's HVAC openings

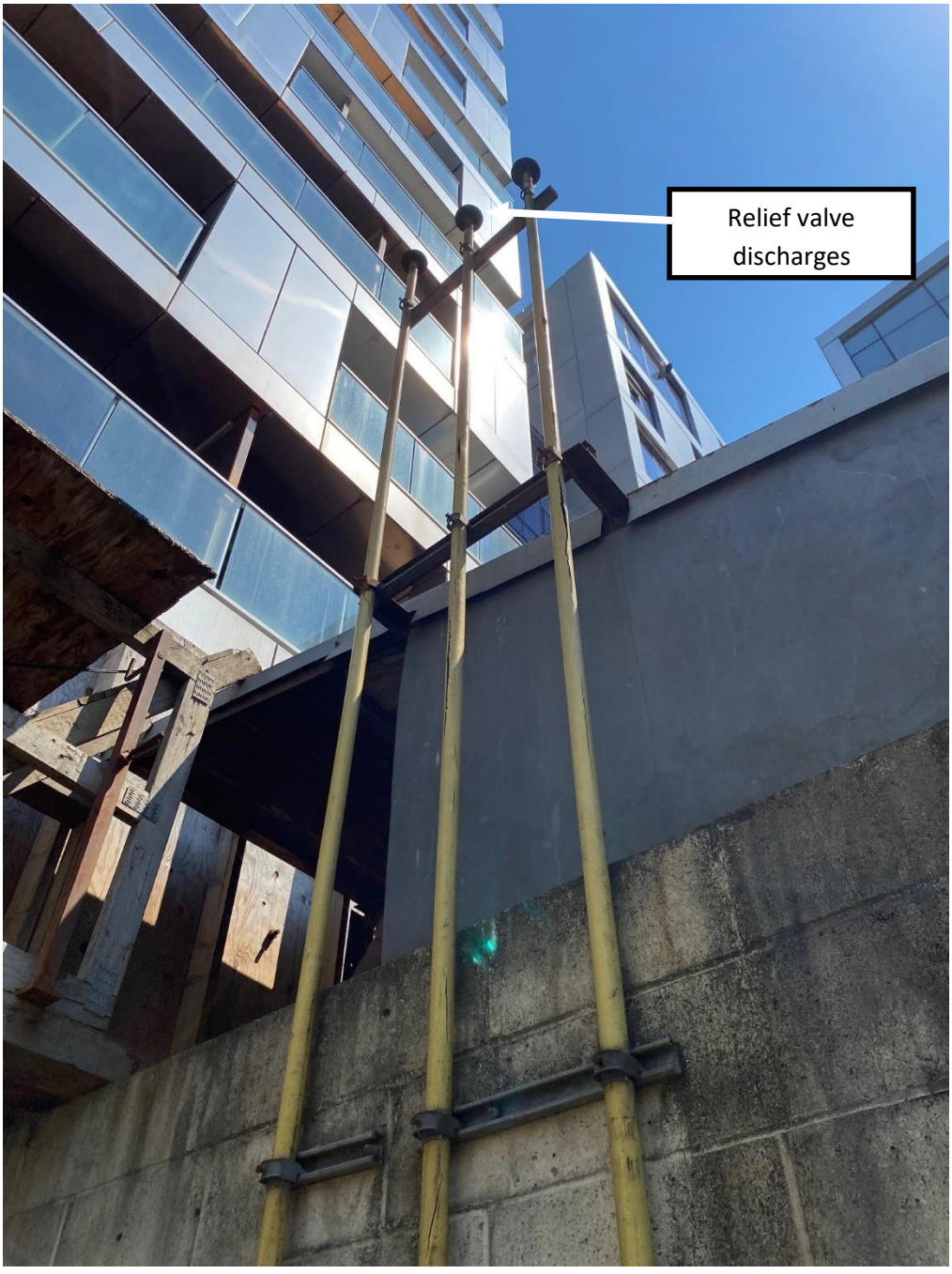

Image 5 – cylinder relief valve discharge

Image 6 – CNG cylinder building and relief valve location

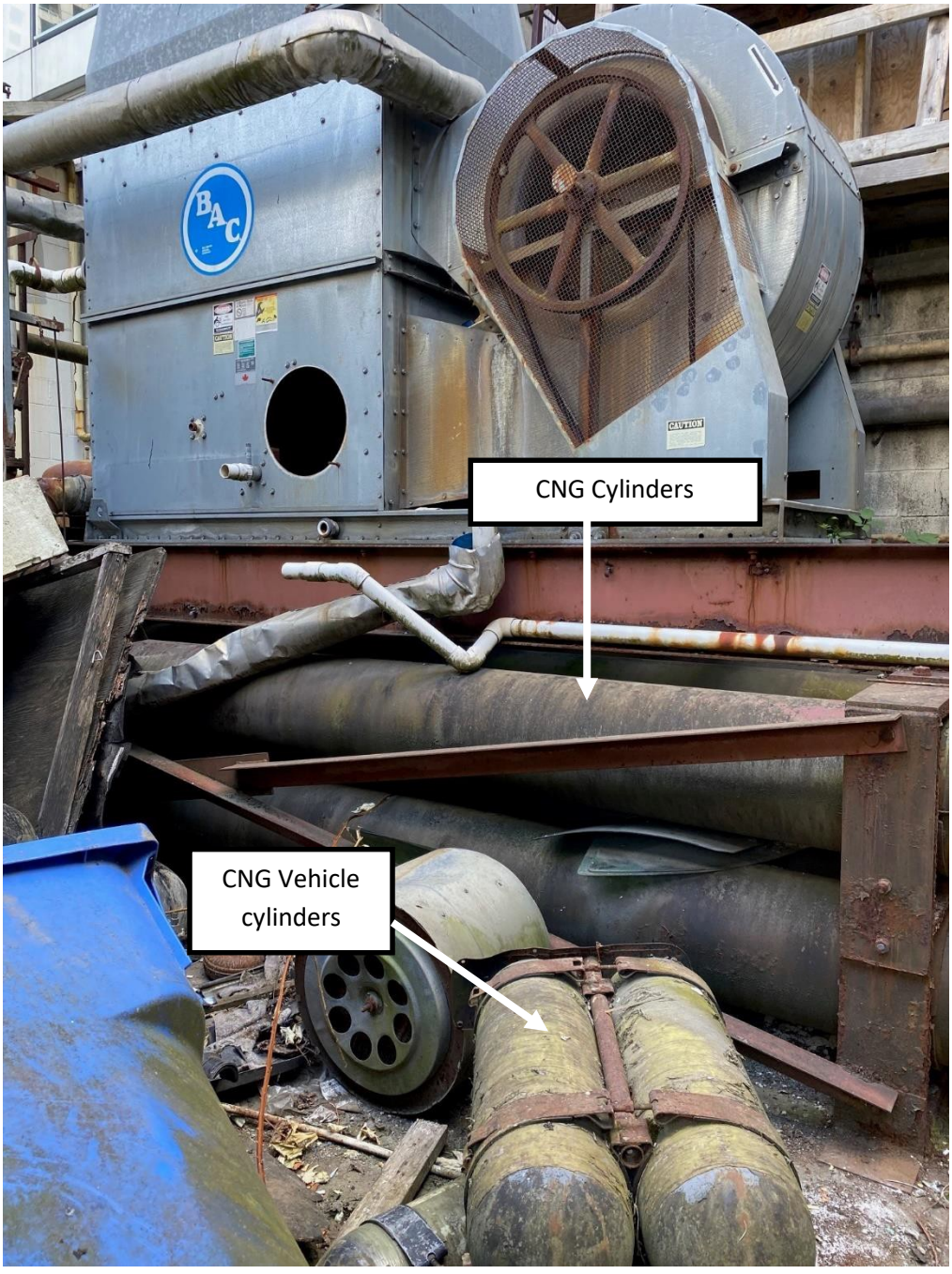

Image 7 – Cylinder location