damaging four other stores badly, and the wreck burned for more than three hours on February 2nd in Eagle Grove, Iowa (Chicago Tribune, 1973). This event caused 14 fatalities; however, the operator of the pipeline could not be found anywhere.

4.2. Pipeline explosion cases in the years 1975–1984

A Nebraska Natural Gas Company employee attended a pipeline leak report after being reached, with difficulty, by the hotel management with the help of police department. However, an explosion still occurred in a natural gas pipeline that destroyed a six-storey hotel in Fremont on January 10, 1976 (Real-McKeighan, 2002; National Fire Protection Association, 2008). There were 20 fatalities and 39 injuries, and glass windows within a one-block radius broke due to the explosion impact (NTSB, 1976). Two years later in Mexico, a similar type of pipeline exploded in Colonia Benito Juarez on the first day of November. This event resulted in 52 fatalities, 11 injuries, and a 300-foot-across by 20-feet-deep crater, and levelled a village with approximately 100 inhabitants, destroying a dozen huts, small restaurants and taco stands (Mott, 1978; The Blade, 1978). The Petroleos Mexicanos (Pemex) stopped the pipeline service and restored it four days later (The Blade, 1976).

On August 16, 1980, a double explosion damaged an underground Shizuoka Japan Railway Station shopping mall, causing 15 fatalities and injuring 223 others (The Free Library, 1998; Zakzak, 2012). Gas leaked from the pipe underneath and accumulated in the underground shopping centre; the explosion was initiated and fire ignited immediately (The Telegraph, 1980). The victims demanded 2.52 billion yen of damages. The Tokyo High Court rejected the claim 16 years later but ordered Shizuoka Gas Company to reach a settlement with the plaintiffs in 1997; only seven plaintiffs’ lawsuits were entertained, i.e., the building owners and the victim’s relatives, at a total of 117 million yen (The Free Library, 1998).

4.3. Pipeline explosion cases in the years 1985–1994

A leaking liquefied natural gas pipeline exploded near Nizhnevartovsk in western Siberia, approximately half a mile from the Trans-Siberian Railway, on June 4, 1989 (Keller, 1989). A total of 462 people died and another 796 were hospitalized. The blast flattened trees within a 2.5 mile radius and blew out windows eight miles away in Asha (Khan and Abbasi, 1999). Twenty acres of forest burned for more than 24 h after the accident. Seven carriages were fully burnt into ash; 37 train cars and two locomotives were destroyed and scattered away from the tracks. Ignition occurred of a highly flammable gas cloud that had drifted from Ufa and accumulated in Russia’s Ural Mountains for hours before sparks from the passing trains ignited the explosion. This type of explosion can only occur due to the mixing of a high volatile (natural gas) to a lower volatile (oxygen) combustible (Sklavounos and Rigas, 2005; Hirano, 2006). The railway tracks were partly demolished (Sputnik International, 2009); railroad traffic was paralyzed and energy supplies disrupted (Keller, 1989). Gazprom’s workers increased the pumping rate when a decline in pipeline pressure was detected (Sklavounos and Rigas, 2005; History, 2009a); the reason behind that act is unknown, but a high pressure level of gas pipeline helps to better locate the leakage point (Xu et al., 2016). The situation became worse when nothing was done to relieve the gas door reported by the residents of the valley (Khan and Abbasi, 1999; Sklavounos and Rigas, 2005). Lax safety procedures and improper work practices were the major cause of this accident (Goldstein, 1989).

In Mexico, a series of 10 explosions of gasoline pipelines in the sewer system of Analco, a Guadalajara city of Jalisco, on April 22, 1992 continued for more than four hours and destroyed eight kilometres of streets (SEMP, 2006). A total of 252 people were killed and almost 500 injured, leaving 15,000 homeless. The large number of fatalities and injuries for this type of explosion is due to the extremely high quantity of combustible gas dispersed in a high density of population in an urban area (Yang et al., 2016). A strong gasoline-like smell was reported to Petroleos Mexicanos (Pemex) by the residents, which became stronger over the four days prior to the event (SEMP, 2006). A city worker inspected the pipeline and discovered high levels of hazardous gasoline fumes, but an evacuation order was discarded, as the city mayor believed that there was no risk of explosion (TIME, 1992). The gas leakage was found later to be caused by the flawed design of the water pipes; local wall thinning may have been incurred to the steel pipe body (Mohsin et al., 2014). Both city officials and the state-owned pipeline operator blamed each other for faulty action (Eisner, 1992); Pemex officials were charged with negligence but later cleared from all charges without any disclosed excuses.

4.4. Pipeline explosion cases in the year 1995–2004

A six-storey shoe store exploded and collapsed in Río Piedras, Puerto Rico on November 21, 1996; 33 people died, and more than 80 were injured (NTSB/PAR-97/01, 1997; Chiroweb, 2015). San Juan Gas Company, owned by Enron Corporation, denied any responsibility and claimed the building had no gas service prior to the explosion. Rumours spread regarding the cause of the explosion—a bomb planted by local terrorists or arson due to previous deliberate acts (Elisevovida, 2010). Nevertheless, gas leaks in the building were reported, and the company’s technicians were sent for inspection. However, no leak could be found due to the lack of inspection training of the employees. The company admitted no wrongdoing throughout the investigation process. A total of 1500 lawsuits were filed; however, 725 were settled outside court; 101 complaints were ruled against the company, and the remaining lawsuits were settled with a total of $28 million, six years later (WOW News, 2002). The owner promised to improve their employee training practices in the future. However, Enron declared bankruptcy in 2001 (Weiss, 2013); the company’s reputation was further tarnished when they were reluctant to settle lawsuits due to bankruptcy (Navarro, 2002).

In 1998, an oil pipeline exploded and incinerated 1078 people on October 18 in the Niger Delta, Jesse, Nigeria (The Associated Press, 2006). The fire was extinguished successfully five days later (History, 2009b). The state-owned Nigerian National Petroleum Corporation (NNPC) claimed the event was caused by scavengers who intentionally ruptured the pipeline and eventually ignited the blaze (Gillis, 2011). However, it was believed that the pipeline failed due to a lack of maintenance and neglect (BBC News, 2003). Two years later, a pipeline owned by the same operator exploded again in Adoje in Warri, killing more than 250 people on July 10 (Johnson, 2000). Buildings and fields within a two-kilometre radius from the epicentre of the explosion point were destroyed and left to be self-extinguished two days later (Johnson, 2000). The cause of the accident was claimed to be similar to the previous accident; many of the dead were seen clutching a fuel bucket as a proof of theft (Dixon, 2000). The pipeline was purposely punctured by street vendors to collect fuel a day before the accident, and they invited the locals to do the same (The New York Times, 2000). Attempts at scavoping and siphoning of fuel are impossible if the pipeline is safely protected (BBC News, 2000).

Another pipeline exploded near the port town on July 16, less than a week after the previous event in Warri, Nigeria. Buckets and wheelbarrows were scattered near the fire, and again, fuel theft was assumed to be the cause. Three years later, in 2003, a petrol