Since 1969 the NTSB (National Transportation and Safety Board) has published 125 documents related to pipeline accidents (NTSB PAR’s (Pipeline Accident Reports) and NTSB PAB’s (Pipeline Accident Briefs)). In addition, Appendix 11 of NTSB PAR 70-1 briefly discusses 12 other pipeline accidents that occurred in 1968 and the early part of 1969. All of these PAR’s and PAB’s are available on the NTSB website in pdf format. I use the term “accidental” inasmuch as that is the terminology utilized by NTSB. Most of these “accidents” were preventable. These “accidents” occurred because of human errors or human assumptions. Few of the accidents actually involved pipeline “failure”.

These errors can be classified as follows:

Construction damage: The use of backhoes and augers in construction without knowledge of existing pipelines has led to a large number of failures.

Puncture of transmission lines during trench preparation has occurred with backhoes, augers, drills, insertion of I-beams, shrapnel damage, and snagging of transmission lines. Most of these “accidents” would have been prevented if trench preparers had bothered to determine if flammable mixture gas or liquid lines existed where the trench is being dug.

Line location errors arise because of faulty mapping or lack of mapping of transmission lines.

The majority of pipeline failures in propane vapor systems are caused by human error.

ODORIZATION OF PROPANE

Propane, normally described as LPG (liquified petroleum gas), is colorless, odorless, and tasteless. At sufficiently high concentrations propane is a simple asphyxiant. The normal boiling point of propane is -44° F. Under 49 CFR 192.625 “A combustible gas (emphasis added) in a distribution line must contain a natural odorant or be odorized so that at a concentration in air of one-fifth of the lower explosive limit, the gas is readily detectable by a person with a normal sense of smell.” At 16 times the human olfactory threshold of an odor 95% of persons with a normal sense of smell will recognize the odor (J. E. Amoore, Odorization, Institute of Gas Technology, 1980, p. 31. The human olfactory threshold for ethyl mercaptan is 1 part per billion (Devos et al., Standardized Human Olfactory Thresholds, IRL Press, Oxford, 1990, p. 70.

The National Fire Protection Association (NFPA) states as a recommendation at NFPA 58, Section A-1-4.1 that, “Experience has shown that ethyl mercaptan in the ratio of 1.0 lb (0.45 kg) per 10,000 gal (37.9 m³) of liquid LP gas has been recognized as an effective odorant.” Liquid LPG is normally odorized with 1.5 lb of ethyl mercaptan per 10,000 gallons of liquid LP gas. This amounts to 25.14 parts per million (ppm) of EM in liquid propane. When LPG is vaporized in a tank only 25.2% of the EM is vaporized, i.e., the distribution coefficient of EM in LPG is 0.252 and the EM concentration in the vapor is 6.34 ppm or 6340 parts per billion (ppb). The human olfactory threshold for EM is 1 ppb. The lower flammable limit for LP gas is
approximately 2% by volume. Thus, at 1/5th the LFL the concentration of EM in the LPG vapor is 25.4 ppb or a safety factor of ca. 2. However, if liquid LPG is emitted into air, all of the EM is vaporized and the EM concentration in air would be 100.2 ppb. At this concentration, the odor would be devastating. The difference in vaporizing propane in a tank and in the atmosphere does not appear to have been recognized by NFPA.

One cubic foot of propane vapor at standard temperature and pressure will produce 47.6 cubic feet of explosive propane/air mixture at the lower flammable limit and 10.5 cu feet at the upper flammable limit.

One cubic foot of liquid propane vaporized at standard temperature and pressure will produce 12,101 cubic feet of explosive propane/air mixture at the lower flammable limit and 2,674 cu feet at the upper flammable limit.

The difference between propane vapor and liquid propane in production of explosive mixtures is 254 times as great for liquid as it is for vapor.

Fortunately, most propane transmission pipelines in residences and elsewhere contain only propane vapor.