John Woodyard
Weston Solutions, Inc.
3/20/05

Behavior of PCBs in Natural Gas

Liquids occur in natural gas as heavier hydrocarbons condense out of the produced gas when temperature and/or pressure are reduced. In systems where the gas is relatively dry (i.e. generally low in heavier hydrocarbons, as is the case at Northern Natural Gas), liquid formation is unusual and generally occurs only when gas quality changes temporarily and unexpectedly. Since these liquids are a mechanical nuisance to natural gas systems, every effort is made to remove the liquids using filters, gravity separators and other mechanical devices. These devices are installed at various locations, usually where liquids are expected to form or collect based on system design (such as low points in the pipeline system) or occasionally where liquids are known from experience to collect.

While rare, situations where condensed liquid is delivered along with the gas are usually the result of an upstream separation system or device being overwhelmed by condensing gas due to temporary (unexpected) changes in gas composition. In these cases, either the liquid plugs the meter and temporarily interrupts gas delivery; a significant slug of liquid is delivered to the combustion unit (which usually extinguishes the burner flame); or the gas flow is sufficiently high (such as for large industrial customers) that the liquid is dispersed as small droplets in the gas stream. The pipeline liquid itself is a hydrocarbon liquid and burns cleanly.

Polychlorinated biphenyls (PCBs) are a blend of chemical compounds that were used in a variety of industrial products because of the chemical and thermal stability. In natural gas systems, PCBs were used as a compressor lubricant and a valve sealant. Because these applications allowed the PCBs to come in contact with the gas, small amounts of PCBs would occasionally enter the gas stream; PCBs are not a naturally occurring component of natural gas. Northern used PCB-containing valve sealant in the northern portion of its system. Northern never used PCB-containing compressor lubricant.

The sale of PCBs for these applications was banned by EPA in 1979. Still, most gas transmission and distribution companies in the Northeastern and Midwestern U.S and Canada have measurable PCBs in their systems, including Northern, for several reasons. First, many gas transmission systems are interconnected, and the use of PCB-containing compressor lubricant in some systems may have resulted in movement of PCBs between systems'. Second, PCBs exist primarily as a liquid or solid at normal gas systems temperatures and pressures, and therefore tend to adhere to piping unless dissolved and moved with other pipeline liquids. Movement of PCBs, if present, is therefore very limited in dry gas systems.
The EPA has known about the presence of residual PCBs in natural gas systems since 1981. Although PCBs are no longer manufactured or sold in the U.S., the EPA regulations governing PCB management and disposal include provisions allowing the continued presence of PCBs in natural gas systems, subject to some management procedures for the liquids and pipeline equipment when they are removed from service. Based on this and other research, EPA long ago established risk-based standards for use of PCBs in industry, for the presence of PCBs in various commercial products including certain foods and packaging, and for the cleanup of PCBs should they be released, all of which are considered to not present an unreasonable risk to human health.

Following the discovery of residual PCBs in natural gas systems, studies were undertaken to better understand the behavior of PCBs in these systems, with an emphasis on ensuring that they were not presenting a risk to customers. The first such study was conducted in 1981 by the New York State Health Department in cooperation with a number of gas distribution companies. This study was designed to determine if gas containing PCBs would result in measurable PCB emissions to the ambient indoor air when burned for cooking. The results of the New York study showed that PCBs did not reach the burner tip, and that ambient PCB levels in residential indoor air was below the lowest established government standard or guideline even when PCBs were known to be present in gas upstream of the delivery points (PCBs were in fact not detected in 80% of the ambient air test samples at a detection limit 100 times lower than the guideline) (8).

The second major study of PCBs in natural gas systems, conducted for the Gas Research Institute in 1988-1995, focused on better understanding how PCBs behaved physically and chemically in natural gas transmission and distribution systems. Through the use of theoretical modeling coupled with laboratory experiments, it was confirmed that PCBs of the type used in natural gas applications exist almost exclusively as liquids within the normal range of delivery temperatures and pressures, and that if present they would tend to adhere to pipe walls, dissolved in pipeline liquids, at low concentrations (<0.01%).

If any liquids are present in a gas system and the mechanical collectors should somehow fail to collect all of it, the accidental delivery of liquid mixed with natural gas to a customer (with or without PCBs) is limited by the design and operation of the system. Movement in the gas stream can only occur when the gas velocity is high enough to move the liquid in small droplets; lower velocity will cause the liquid to drop out, where it is collected using the gravity separators mentioned earlier or on rare occasion accumulates in meters or regulators.

In the unlikely event a measurable amount of PCB-containing pipeline liquid is introduced into a customer's furnace, the fate of the pipeline liquid and any PCBs will depend on the design and operation of the furnace. PCBs boil (become vapor) at temperatures above 600F, and therefore are almost entirely a liquid, in natural gas, at delivery pressures. In a typical heating system or commercial/residential boiler, the operating temperature throughout the furnace would not be high enough to vaporize the PCBs, so they would remain in the furnace, in liquid state even after the light-end pipeline liquids burn off. The remaining liquid, which would contain the PCBs, could then be sampled and removed.

Because of their thermal stability, PCBs are completely burned only at extremely high temperatures and only when held at that temperature for a period of time (termed residence time). The EPA's PCB regulations governing the design and operation of incinerators for PCB destruction require that they be operated at over 2000F for at least 2 seconds residence time, well beyond the limits of even most industrial furnaces and electric utility boilers. It has been shown that most commercial and industrial customer furnaces would therefore not destroy PCBs. However, minute amounts of PCBs that actually get to the flame could be vaporized but will, more than likely recondense before exiting the combustion chamber with the exhaust. As a point of reference, a gallon of pipeline liquid with 100 ppm of PCBs would contain 0.01 ounce of actual PCB. Burning of liquids (usually transformer oil) containing up to 500 ppm PCB is permitted in power plants.

While PCBs do not readily burn, exposure to temperatures that are not sufficient to destroy it can still cause some PCBs to form by-products other than the normal products of combustion (water vapor, CO2, and hydrochloric acid). This phenomenon was first discovered following several incidents of PCB combustion involving electrical transformer failures where high concentration PCB (50%) was burned under very specific conditions (optimally 1250 degrees F for 0.8 seconds or more). Although often erroneously reported, the creation of dioxin compounds from the incomplete combustion of PCBs is chemically impossible. Incomplete combustion of the PCBs can occur at lower temperatures and residence times, but only to a limited extent, and under certain circumstances can create dibenzofurans (a dioxin-like chemical but 10 to 10,000 times less toxic). Even under optimal combustion conditions in the laboratory (i.e., where someone is intentionally trying to create these by products), only a small percentage of PCBs are converted to dibenzofurans.

In summary, PCBs are present in some natural gas systems as a contaminant, and move through the system as a liquid dissolved in other pipeline liquid hydrocarbons. Pipeline liquids are collected by gas suppliers in filters or other special devices, the design of which is well established and effective. On rare occasions, pipeline liquids may reach a customer meter, but any PCBs (if present) will not burn and will stay largely in liquid form where they can be removed with the gas equipment or cleaned. Test results of ambient air in residential settings where PCBs are present in natural gas have shown ambient PCB levels in the air to be well below any established standard. In the event PCB-containing liquids reach a customer's furnace, either the flame would be extinguished and PCBs remain in the furnace, or the PCBs would be vaporized and exit with the exhaust gas, if the exhaust gas were hot enough to keep the PCBs in a gaseous phase, or the PCBs would vaporize and then recondense and fall back into the furnace chamber. For example, 10 gallons of liquid at a high PCB concentration of 1,000 ppm would, more than likely, result in undetectable PCB levels, including any by-products, in the exhaust.

References

Erickson, Mitchell D. *Analytical Chemistry of PCBs*. Second Edition. Lewis Publishers. 1997

Katz, Donald L. and David F. Bergman. Condensate Formation in Natural Gas Pipelines. Am. Gas Assoc., Oper. Sect., Proc. 75-T-41 (U.S.) (1975).

Weston Solutions, Inc. Proceedings of the Workshop on PCB Migration and Control in Natural Gas Pipelines, San Antonio, TX, January 1994. GRI Topical Report GRI-94/0028. November 1994.

Code of Federal Regulations Section 40, Part 761. Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce and Use Prohibitions (7-1-03 Edition)

Linz, D.L., J. P. Woodyard, M. Adewumi, and M. Tomson. GRI's Pipeline PCB Migration Control Research Program: Purpose, Status and Plans. June 1995.

Weston Solutions, Inc. Understanding, Modeling, and Controlling the Movement of PCB in Natural Gas Systems. GRI Topical Report GRI-99/0258. June 2000.

New York Gas Group. An Assessment of the Possible Impact of Natural Gas Use on PCB Levels in Indoor Air. Conducted under the direction of the New York State Department of Health, Bureau of Toxic Substance Assessment. April 1982.

Versar, Inc. PCBs in the United States: Industrial Use and Environmental Distribution. EPA Report 560/6-76-005. February 1976.