



## Chlorine Odors in Poultry Processing Plants

There are potentially three types of airborne irritants encountered in poultry plants that can be caused by chlorination.

One irritant is caused by the use of excessively high concentrations of chlorine (typically sodium hypochlorite) that results in detectable amounts escaping to the atmosphere. Another type of airborne irritant occurs when free chlorine combines with organic compounds to produce organochloramines, some of which are relatively insoluble and can cause odor problems in the plant. The third airborne irritant occurs in the presence of ammonia when the chlorine to ammonia ratio increases to a point where nitrogen trichloride is produced. This condition is common to poultry plants that receive chloraminated city water and then treat the water with a source of free chlorine.

This paper addresses chloramines, both organic and inorganic.

### Inorganic Chloramines

Inorganic, or true, chloramines are produced by the controlled mixing of chlorine and ammonia in potable water. The three species of inorganic chloramine that can be formed by the chlorine-ammonia reaction are monochloramine ( $\text{NH}_2\text{Cl}$ ), dichloramine ( $\text{NHCl}_2$ ) and nitrogen trichloride ( $\text{NCl}_3$ , also known as trichloramine).

Monochloramine is the preferred chloramine species for use in disinfecting drinking water and is in widespread use in potable water distribution systems. Monochloramine is odorless and highly soluble in water. Dichloramine and nitrogen trichloride are not desirable because they are less soluble in water and can be the source of taste and odor issues. Nitrogen trichloride is highly insoluble, is easily stripped from water by aeration, and is the only inorganic chloramine species that can cause burning of the eyes and nasal passages. The species of chloramine that is produced when combining ammonia and chlorine can be selected in large part by controlling the chlorine to nitrogen ( $\text{Cl}_2:\text{N}$ ) ratio. To ensure that only monochloramine is formed, current practice is to use a  $\text{Cl}_2:\text{N}$  ratio in the range of 3:1 to 5:1, with a typical value of 4:1. Ratios less than 5:1 result in the presence of monochloramine and some excess ammonia in the distribution system.

Once a potable water source has been chloraminated, any subsequent addition of chlorine can cause off-gassing of obnoxious chlorinous odors. This can occur even when the monochloramine or ammonia levels appear to be too small to make a significant difference. Due to the chemical properties of the compounds involved, the concentration of the irritant produced ( $\text{NCl}_3$ ) will be higher than the concentration of the ammonia or the monochloramine that contributed to its production.<sup>1</sup> One ppm of ammonia combined with 6 ppm of free chlorine produces about 7 ppm of nitrogen trichloride, while 1 ppm of monochloramine combined with 1 ppm of free chlorine produces about two parts per million of nitrogen trichloride. Therefore, if a processing plant chlorinates a water supply that carries 1 ppm residuals of monochloramine and ammonia, 9 ppm of nitrogen trichloride will be produced.

Any poultry processing plant that chlorinates a chloraminated water supply should expect off-gassing issues. Even if the residual levels of ammonia and monochloramine being received by the plant are less than 1 ppm, if either compound is present at all, some level of nitrogen trichloride will constantly be produced as new source water is chlorinated and introduced to the process. Small amounts of nitrogen trichloride continually introduced to the environment will compound worker safety issues as exposure times and possibly concentrations increase during the work day.

#### Organic Chloramines (Organochloramines)

An entirely different set of compounds, known as organochloramines, result from the chlorination of organic material, as in a poultry chiller. These compounds are responsible for causing foul tastes and odors in some drinking water systems. Some of these compounds are relatively insoluble and can readily off-gas and cause worker irritation.

Organochloramines are responsible for producing the chlorinous odors commonly encountered in swimming pools, and are often described as “chloramines,” even though they are not true chloramines, which are inorganic.

There are currently no specific air quality detection tests for either organic or inorganic chloramines.

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<sup>1</sup>Chemically, when one mole of ammonia ( $\text{NH}_3$ ) combines with three moles of free chlorine ( $\text{Cl}_2$ ,  $\text{HOCl}$  or  $\text{OCl}$ ), one mole of nitrogen trichloride ( $\text{NCl}_3$ ) is produced. Similarly, when one mole of monochloramine ( $\text{NH}_2\text{Cl}$ ) combines with two moles of free chlorine, one mole of nitrogen trichloride is also produced. However, moles are not convenient units of measurement, so they are converted to units that can be more readily measured and controlled, such as weight per volume. One commonly used weight/volume ratio is milligrams per liter (mg/L), which is also referred to as parts per million (ppm). The conversion from moles to parts per million is accomplished by calculating and comparing the molecular weights of the compounds involved.