REMOVAL OF HYDROGEN SULFIDE BY AERATION

It is a straight forward task to determine the theoretical amount of air which is required to oxidize and precipitate hydrogen sulfide from water. The actual amount of air can then be estimated quite accurately so as to determine the correct Mazzei Injector to use and the recommended operating conditions for that injector.

A. Water Chemistry

Water pH is less important in the oxidation of hydrogen sulfide than in the oxidation and precipitation of iron and manganese. For hydrogen sulfide, the water pH should be at maintained in the range of 6.8 to 7.5. This allows the hydrogen sulfide to dissociate into its ionic form $H_2S \rightarrow 2H^+ + S^{-2}$. The sulfide ion is then free to react with oxygen.

B. Other Factors

Air oxidation of hydrogen sulfide is not instantaneous. For this reason it is advisable to employ a retention, or contact tank to allow for sufficient residence time for complete oxidation and precipitation to occur. Depending upon actual conditions, contact times may range from 5 to 15 minutes.

C. Formulas

The following reaction describes the oxidation of hydrogen sulfide by oxygen

$$2H_2S + O_2 \rightarrow 2H_2O + 2S$$

NOTE: S is elemental sulfur

D. Ratio

The atomic weight of sulfur is 32.06. One oxygen molecule reacts with two sulfur atoms. The molecular weight of oxygen is 31.999. The reaction ratio is thus (31.999) / (32.06), or 0.9981, or 1.0. This means that ±1.0 mg/l of oxygen is required for each mg/l of hydrogen sulfide (measured as sulfide).

E. Oxygen Residual

Sufficient air must be injected to maintain the required oxygen residual. Maintaining an oxygen residual serves several purposes. First, it provides a buffer of oxygen to react with surges of hydrogen sulfide. Second, it produces a more palatable water. Third, the air required to maintain the oxygen residual provides mixing so that hydrogen sulfide can react quickly and efficiently with oxygen. An accepted value of residual oxygen is 5.0 mg/l. Sufficient air must be injected to maintain this level. The initial oxygen level in waters with hydrogen sulfide present is typically zero. If there is an initial oxygen residual present, this may be subtracted from the desired level of 5.0 mg/l when determining the amount of oxygen required.

F. Theoretical Oxygen Required

The theoretical amount of oxygen required to oxidize hydrogen sulfide may be calculated from the following formula:

Oxygen Required = $[X_s \ (S)] + R$, where

X_s = Hydrogen sulfide reaction factor
(S) = Hydrogen sulfide concentration in mg/l (as sulfide)
R = Final oxygen residual = (5.0 – Initial Oxygen) in mg/l

An example for (S) = 25 mg/l and Initial Oxygen = 0.0 mg/l:

Oxygen Required = (1.0)(25) + (5.0 –0.0)
= 25 + 5.0
= 30 mg per liter of water flow

G. Theoretical Air Required

Air has a density of 1.2047 g/l at 20o C. and 1.0 atmosphere of pressure. Under these same conditions, air contains 20.95% oxygen. Thus, each liter of air contains (1.2047 g/l)(0.2095) = 0.2524 g/l of oxygen = 252.4 mg/l of oxygen. In order to determine the theoretical amount of air required for oxidation of hydrogen sulfide, the water flow rate must be known. If the level of hydrogen sulfide is known, a convenient unit of flow is “per 1,000 liters”.

For example, using the contaminant levels in the previous example, and a flow rate of 100 l/min, the theoretical amount of air required would be:

$$\frac{(100\ \text{l/min})(30\ \text{mg/l})}{(252.4\ \text{mg/l})} = 11.89\ \text{l/min of air}$$

Using this value, the theoretical amount of air required would be 118.9 liters per 1,000 liters of water.

H. Actual Amount of Air Required

The oxygen transfer efficiency of aeration devices ranges from a low end of 5% to a high end of 25% to 35% for Mazzei Injectors. A figure of 25% for Mazzei Injectors is conservative and is supported by both laboratory and field data. This means that the actual amount of air required is approximately four times the theoretical amount of air required.

For the examples above, if the theoretical amount of air required is 11.89 l/m (or 118.9 liters per 1,000 liters of water), the actual amount of air required would be four times this amount or 47.6 l/m (or 476 liters per 1,000 liters of water). Depending upon particular circumstances, it may be wise to add to this amount an additional "safety factor" of 10% to 20%.

To aid in converting to English Units:

1 l/m of water flow	=	0.264 gal/min
1 gal/min of water flow	=	3.785 l/m
1 l/m of air flow	=	0.03531 ft^3/min
1 ft^3/min of air flow	=	28.3 l/m