KEEPING OZONE COSTS IN CHECK

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A wealth of technical information about ozone is now available: historical facts about early applications, graphs showing proper ozone dosages for a variety of water problems and articles comparing the myriad of ozone generating equipment on today's market.

While ozone is a very powerful, effective oxidizer of organic contaminants, it also has a reputation for being a somewhat expensive water sanitation alternative. This article takes a more non-technical, practical look at ways to keep the costs of ozone in check and presents guidelines to help you understand what to look for - and what to avoid - when selecting ozone equipment.

Know Your Water

The well-documented issue of properly matching the amount of ozone required for each application has a significant influence on an ozone system's overall cost. Effective dosage rates vary according to the amount of each contaminant present, making a thorough water analysis an important prerequisite to any equipment purchase. For example, 1 mg/L of iron can be treated effectively with approximately 0.14 to 0.50 mg/L of ozone, while the same amount of hydrogen sulfide requires about 0.60 to 1.50 mg/L of ozone (from "A Look Into the Future of Ozone", by Steve Andrews, WC&P, March 1991). Knowing which contaminant(s) are present in the water (and at what levels) will help determine the appropriate ozone output required. Purchasing an oversized system can be an obvious waste of money, and buying a system that is too small for the job can end up costing you in additional chemicals and/or filtration equipment.
Once you have determined what contaminants are present and require oxidation, the next step is to look for an ozone system that will provide the necessary ozone output and concentration while offering the best overall value. A typical system includes the ozone generator, air preparation (for corona discharge ozone generators), and injection/contact equipment.

The Ozone Generator

The system's initial cost can vary widely depending on the peripheral equipment included, options available and the type of ozone technology offered by the manufacturer. Generators utilizing an ultraviolet lamp for ozone production are usually the least expensive, but ozone output relative to unit size is lower. Also, the concentration of ozone produced is significantly lower than corona discharge generators (about .1% compared to approximately 1.0 to 1.5% by weight).

It is a fact that the solubility of ozone in water is increased by the concentration of ozone generated. For example, given a water temperature of 77 degrees F., an ultraviolet ozone generator producing a .1% concentration will yield an equilibrium ozone water solubility level of 0.35 mg/L. In comparison, a corona discharge ozone generator producing a 1.5% concentration by weight will yield a solubility level of 5.29 mg/L (Stover et al., 1986). Because of the greater ozone concentrations and solubility levels produced by corona discharge systems, they can be a cost effective alternative. Again, a critical factor in minimizing costs is to effectively determine the ozone dosage required for the application.

Corona discharge ozone generators can be divided into two general categories - high frequency/plate designs and cold plasma (also referred to as cold cathode). Both types produce higher ozone concentration levels than ultraviolet equipment, but usually carry a heftier price tag. The more standard corona discharge ozone generators utilizing high frequency or plate designs generally produce the highest concentration of ozone (up to 6% by weight depending on the design and the feed gas) and require the least amount of maintenance since a lamp is not involved in ozone production process. While the lamp in an ultraviolet ozone generator is quite different from that in a cold plasma unit, both will require periodic replacement.

Whether it is determined that an ultraviolet ozone system fits the application or that corona discharge equipment is required, always look for quality components. Since ozone is such a powerful oxidizer, it can rapidly degrade many materials, including most rubber compounds, many types of plastics (including PVC) and some metals. Make sure the internal parts that may come into contact with the ozone gas are constructed of ozone resistant materials, such as high grade stainless steel, Teflon®, Viton® and Kynar®. Ultraviolet ozone generators should be designed so the wiring and electrical components are not exposed to ultraviolet light or ozone, since both will degrade many plastic and rubber materials.

Air Preparation

If the application warrants a corona discharge ozone generator, some sort of air preparation system must be included. These systems fit into three general categories - air dryers, oxygen concentrators and pressurized oxygen tanks. Increasing the concentration of oxygen and reducing the moisture content in the feed gas not only improves the output capability of the ozone generator (by up to 50%), but is also critical to keeping long term maintenance costs in line.

Air dryers are the least expensive air preparation method. Three basic types of dryers are currently available: Replaceable desiccant, heat regenerative desiccant and pressure swing adsorption. Replaceable desiccant dryers are relatively inexpensive but require regular changes of the desiccant. Pressure swing adsorption dryers produce the driest air but are quite mechanical and therefore require the most maintenance. With today's technology, heat regenerative desiccant dryers probably represent the best value in terms of performance, convenience and maintenance requirements.

While air dryers do not significantly increase the output of the ozone generator, they are effective in drying the air to a dew point of about -60 degrees F. This is important because moisture combines with nitrogen in the feed gas to form corrosive nitric acid during the ozone production process. The accumulation of this nitric acid will rapidly deteriorate critical internal parts of the ozone generator, restrict the flow of the ozone gas and contaminate the dielectric, resulting in reduced ozone production and increased maintenance costs.

Oxygen concentrators not only dry the feed gas up to a -80 degree F. dew point, but remove a large percentage of the nitrogen as well. Nitrogen is actually more abundant in ambient air than oxygen (about 78% vs. about 20%) and its removal from the feed gas increases the concentration of oxygen, which leads to improved ozone output and concentrations. Depending on the type of ozone generator, the concentration of ozone by weight can be increased by up to three times.

Oxygen tanks afford the purest possible feed gas. However, the tanks can be expensive and represent a safety hazard. The inconvenience of delivery and changing the tanks should also be considered. Oxygen concentrators need periodic maintenance and have electrical requirements, but the oxygen used by the ozone generator is produced on-site.

The cost and type of air preparation system will vary according to the size of the ozone system specified. Air preparation is a necessary component of corona discharge ozone systems and will provide long term savings by increasing the efficiency of the ozone generator and reducing maintenance costs.

Injection/Contact Equipment

Since ozone is only partially soluble in water, a very dynamic injection process is required for effective mass transfer. The ozone bubbles must be as small as possible in order to increase the ratio of bubble surface area to the amount of ozone gas entering the water. Greater total surface area of the ozone bubbles means more ozone will be dissolved into the water.

An injection system that is properly designed for ozone introduction is capable of achieving a mass transfer efficiency rate of 99%. The injector produces a cavitation effect that enables the ozone gas to join the water stream in the form of extremely tiny bubbles. A diffuser stone emits larger bubbles (and with no force), so the transfer of ozone into the water is much more passive and less efficient.

The best choice in injection systems will depend on the size of the application, the physical layout, and the components involved. If ozone is efficiently transferred into the water, the output of the ozone generator will be maximized. Again, system efficiency translates into cost savings.

System Operation and Maintenance
When evaluating the costs associated with system operation and maintenance, overall reliability and power consumption must be considered. Ultraviolet units have similar ratios of power consumption to ozone output, but energy requirements for corona discharge systems can vary. Generally, ozone generators using high frequency or plate designs use less power than their cold cathode counterparts and do not require periodic lamp changes. Other maintenance costs, including filter changes and air preparation system upkeep, are minimal.

Summary
Keeping the cost of an ozone system in check requires careful research on the variety of ozone equipment available and an understanding of the contaminants that need to be controlled. Ozone technology can be cost effective, especially considering the fact that it has tremendous oxidation capabilities and is generated on-site. Benefits of ozone water sanitation include its superior ability to kill bacteria and viruses and remove undesirable taste, odor and color from the water while leaving no harmful by-products.

To minimize the cost of your ozone system, make sure the ozone output and concentration match the amounts required to control the contaminants present in the water. Once these sizing requirements have been determined, evaluate prospective ozone systems on the following general criteria:

- Reliability of the ozone generator and air preparation equipment
- Power consumption of the components involved
- Initial equipment costs

The recent growth in the ozone market is fueling improvements in ozone technology, making systems more efficient and cost effective. Ozone is a very powerful and safe oxidizer of organic contaminants, making it an important part of today's water treatment systems.