OZONE 101

What is ozone?

Ozone is a chemically unstable gas consisting of three atoms of oxygen. It is formed naturally in the atmosphere by the action of lightning and of ultraviolet radiation. It plays an important role in the upper atmosphere, absorbing wavelengths of ultraviolet radiation harmful to 1ife.

Ozone is a powerful oxidizing agent which is effective in both liquids and gases. It is highly reactive and is considered a toxic gas, with a recommended exposure limit of 0.1 ppm over an eight hour period. However, the high reactivity means it is an unstable gas with a short half-life and it has a pungent odour which is readily detectable well below the toxic level.

Uses

The oxidizing power of ozone can be used for:

- disinfection
- removal of metal ions
- removal of colour and odour compounds
- oxidation of synthetic organic compounds
- chlorinated byproduct control
- pretreatment of water and waste water

Disinfection

Ozone can eliminate or inactivate bacteria, viruses and parasites by oxidizing the chemical components of their cells. The amount of ozone required for a particular application depends on the quality of the water or waste stream, the efficiency of the contacting apparatus and the disinfection criteria that need to be met.

Metal removal

Ozone removes metal ions by oxidizing them to a less soluble form which can be precipitated out.

Colour and Odour

Natural organic compounds make a significant contribution to the colour of water. Upon exposure to ozone these are oxidized and the colour greatly reduced.
Odour and taste compounds, which usually contain sulphur or nitrogen, become unstable and break down after exposure to ozone.
Algae are a primary source of colour and odour and are effectively treated by using ozone as a microfloccu-lant.

Chlorinated byproduct control

The exclusive use of ozone or, alternatively, the pretreatment of water by ozone prior to chlorination eliminates or significantly limits the formation of trihalomethanes (THMS) and organically bound chlorine compounds.

Pretreatment

Ozone can be used to break down resistant waste water material so it is more readily absorbed, or into biodegradable species that can be treated by standard biological treatment processes. Ozone also aids formulation.

How Effective is Ozone?

A commonly used measure of germicidal efficacy is the CT value which is a function of the germicide concentration [C] and its contact time [T] with the liquid stream. The value is specific for a nominated inactivation of the indicator organisms e.g. CT_{99} is the CT value necessary for 99% inactivation.

Ozone is a very powerful disinfectant and is particularly useful in treating chlorine resistant species. The following table compares the efficacy of different disinfectants for several micro-organisms.

The more effective a disinfectant, the lower the CT value. In each example in the table below, ozone is the most effective disinfectant.

CT values for the inactivation of micro-organisms at 5°C

Microorganism	Free chlorine*	Chlorine dioxide	Ozone
E. coli : CT_{99}	0.034 - 0.05	0.4-0.75	0.02
Polio virus 1: CT_{99}	1.1 - 2.5	0.2 - 6.7	0.1
Giardia lamblia cysts: CT_{99}	125	-	0.53
Cryptosporidium cysts: CT_{90}	7200	78	5

* Examples of free chlorine are chlorine gas or hypochlorite.

Benefits

Chlorinated by-product control

In recent years there has been growing concern regarding the formation of chlorinated disinfection by-products in water treatment when using free chlorine agents. The disinfection by-products of particular concern are the THMS, such as chloroform, which are formed by the reaction of chlorine species with organic material present in the water supply. THMS are potentially carcinogenic.
Using ozone exclusively as a disinfectant eliminates the formation of THMS and other organically bound compounds, while the use of ozone as a pretreatment step prior to chlorination can significantly reduce their formation.

Aesthetic benefits

Using ozone for treating potable water means undesirable natural odours and tastes are removed without the addition of a residual chemical after taste and odour.

Disinfection

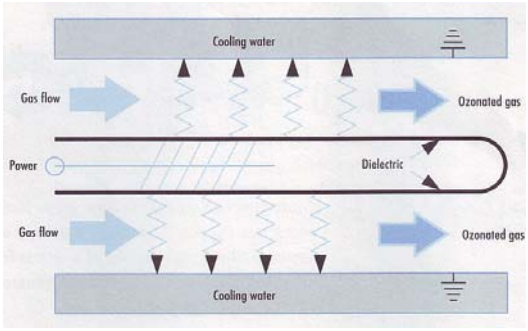
Ozone is more powerful than chlorine based disinfectants and is particularly useful when parasites such as giardia or cryptosporidium need to be treated.

Creating ozone

The ozone generator

Ozone can be made by a variety of methods including the use of UV lamps and electrochemical methods. By far the most common method used in industry is the corona discharge method owing to its higher ozone yield and better energy efficiency.
In the corona discharge ozone generator, electric power is supplied to a unit which consists of two electrodes separated by a dielectric material (e.g. glas) and a small air gap. The dielectric material has a high ionising potential which requires an applied voltage of about 10,000 volts or greater before electrons will begin to move between the electrodes, completing the circuit.

Corona discharge ozone generator



The collision of the electrons with the oxygen molecules the introduced gas stream results in the formation of some ozone molecules. The amount of ozone formed is dependent on the characteristics of the electrical supply and the temperature of the treated gas.
In order to maintain the dielectric quality and to optimism the electrical energy use (ie. maximise kg O3/kWh) it is necessary to provide cooling sufficient to maintain the ozonated gas stream below 20ºC, as ozone decomposes at higher temperatures. The production rate of ozone is normally controlled by modulating the electrical supply.

Gas preparation equipment

Ozone generators can be either air or oxygen fed. Oxygen (from an external or integrated supply) generates a much higher ozone yield. Oxygen can be supplied by a variety of methods such as pressure swing absorption (PSA) or cryogenic plants.

An important requirement for ozone generation is adequate pretreatment of the supply gas. In order to minimise maintenance problems and maximise ozone production, it is recommended that the supply gas be dried to a minimum dew point of -50ºC and preferably less than -60ºC. The preparation unit must effectively dry and filter the gas supply.

Ozone injection equipment

Injection equipment is necessary to facilitate effective dissolution of ozone into the process stream.

A variety of configurations are available, one of which is venturi injection which creates ultrafine bubbles and dissolves the ozone very efficiently into the water.

New Zealand Applications

Potable water: mineral water bottling, brewery, small council public supplies, schools, camping grounds, motels, chicken and dairy farms.

Swimming pools: Regional Aquatic Centre (Wellington), Waiwera, Swimarama and the Waitakere City Aquatic Centre (Auckland).

Aquarium: Kelly Tarltons.

Odour control: local authorities including North Shore, Hamilton and Lower Hutt.
Trials on pulp and paper and meat rendering odour.

Cooling towers: Rothmans Tobacco Co. (Napier), Transpower HVDC link (Haywards Hill), State Services building and National Library (Wellington).

Glossary

Carcinogenic- Cancer producing

Chlorinated- Containing chlorine as part of the molecule.

Corona discharge- A high voltage, nearly continuous spark which excites the gas it passes through to create a glow or corona.

Cryogenic oxygen- Oxygen stored at a temperature to maintain it in a liquid form. It would be supplied on site in this form.

Cryptosporidium- A parasitic protozoon which causes a severe intestinal infection in humans.

Disinfection- The process by which disease causing micro-organisms are destroyed.

E. Coli- A type of bacteria which indicates the presence of faecal matter.

Flocculation- The formation of large groups of fine particles.

Giardia lamblia- A parasitic protozoon which causes a severe intestinal infection in humans.

Microflocculant- An agent which assists with the removal of unwanted particles.

Pressure or volume swing absorption-Techniques for producing pure oxygen from air. Can be installed on site with the ozone system

Protozoon- A microscopic animal.

Trihalomethanes- Carcinogenic byproducts of, for example, chlorination.