Microwave UV Disinfection – An Everlasting Lamp?

Many of you working in the water and wastewater industry will have observed the emergence of Ultraviolet (UV) technology as a player in the world of disinfection over the past 10-15 years. This article will provide a brief introduction to UV technology and outline a recent advancement in the field: - the generation of UV light using microwave energy instead of electrical energy.

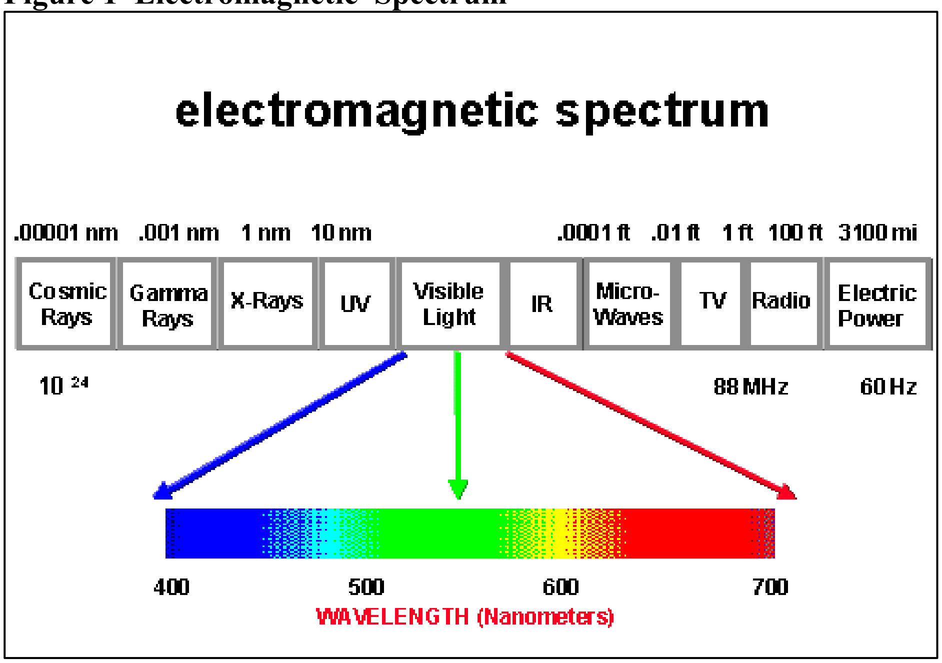
UV – A Natural Disinfectant

There is nothing inherently new about UV disinfection. Sunlight has long been recognised as a natural disinfectant. Ultraviolet light is absorbed by DNA disrupting the bonds between the DNA bases and thereby inhibiting the ability of the organism to replicate. It is this same property of UV light that can lead to skin cancer.

This same phenomenon was occurring in the primordial soup 3.5 billion years ago, where it is speculated that high levels of UV radiation in Earth's early atmosphere caused mutations that led to development of more complex microorganisms.

Ultraviolet light is part of the electromagnetic spectrum. This is a broad spectrum encompassing gamma rays at one end and radio waves at the other end as shown in Figure 1. Visible light occupies an area towards the middle of this spectrum and to the left of visible light is the UV range. UV light is further divided into UVA UVB and UVC (refer to Figure 2). For the purposes of disinfection UV light with a wavelength of 254nm is the most effective wavelength and this falls within the UVC range.

Figure 1 Electromagnetic Spectrum



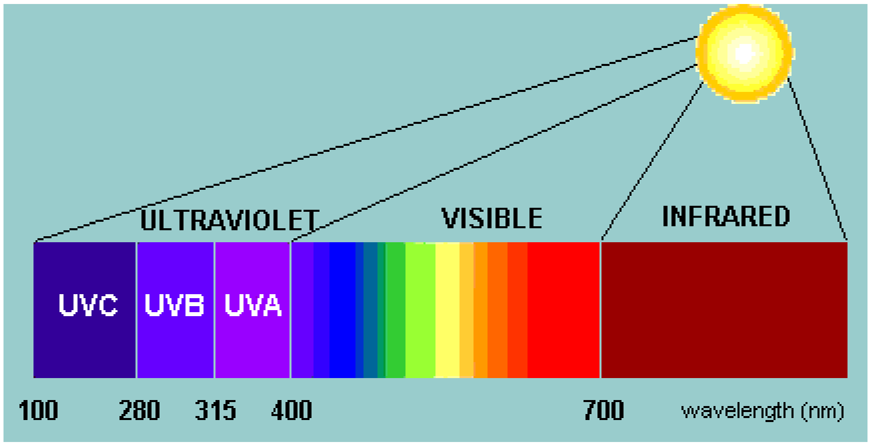


Figure 2 Ultraviolet Range of the Electromagentic Spectrum

The first scientific discovery that UV light inactivated microorganisms was made in 1878 by two English scientists, Thomas Blunt and Arthur Downes. In 1903 it was discovered that the most effective wavelengths were in the region of 250 nm. Following this the technology underwent a period of development with significant progress made by the 1940's. UV light is currently widely used for both drinking water and wastewater disinfection and has received particular attention in recent years for the treatment of drinking water due to the fact that it is effective against cyst forming bacteria such as *Cryptosporidium* and *Giardia* which are resistant to chlorine disinfection.

An Alternative System for Generating UV Light

The basic objective of any UV system is to impart enough energy to the mercury gas in the lamp to cause it to emit UV light. The most common way of providing this energy to the gas is by applying a potential difference across the lamp using an electrode. The potential difference across the lamp causes particles to be accelerated and when they collide their kinetic energy causes electrons in the gas to enter a higher orbital. As the electrons return back down to their normal energy state they emit the excess energy as Ultraviolet light.

An alternative method of generating UV light is to use microwave energy, as opposed to direct electrical energy, to excite the gas in the lamp. Microwaves are directed into the lamp and excite the mercury gas, the electrons enter an excited state and when they come back down to base, they emit the excess energy as…. UV light.

As you are not using direct electrical energy to excite the gas, there is no need for an electrode in the lamp thereby eliminating the primary cause of lamp failure. In medium pressure and low pressure systems when the electrode fails the lamp has to be replaced. The lifespan of low pressure lamps varies from manufacturer to manufacturer, but typical warrantees range from 8,000 hours to 12,000 hours with lamps typically replaced at least annually. In a microwave UV system the lamps are warranteed for 3 years with some installations operating for over four years without being replaced.

So how does it work? The system uses a low pressure mercury amalgam lamp. Figure 4 is a photograph of one of the lamps used. It is identical to the low pressure lamp shown in Figure 3, except without an electrode. Four lamps are bundled together and inserted into a wave guide. A wave guide is simply a wire mesh which stops microwaves from escaping. Next time you are standing in front of your microwave oven, look at the wire mesh in the front door, that's a wave guide. It's designed to keep those microwaves inside but allows light in and out. The lamps and waveguide are inserted into a quartz sleeve. Four quartz sleeves are assembled into one rack as shown in Figure 5. Each quartz sleeve is fitted with a microwave source or 'magnetron'. The system uses standard off the shelf magnetrons identical to those used in a home microwave oven manufactured by any of the major electronics firms such as Siemens or Phillips. The metal box shown on top of the lamp assembly in Figure 5 contains a magnetron and also houses the cleaning mechanism. Stainless steel brushes are used to prevent fouling of the quartz sleeve.

Figure 3 Conventional Electrode Lamp

Figure 4 MicroDynamics™ Electrodeless Lamp

The lamps operate at between 60 – 80 degrees Celsius. A small fan is used to evacuate warm air from inside the quartz sleeve. This helps to ensure that the quartz sleeve is at the same temperature as the surrounding water reducing fouling and eliminating the potential for overheating in periods of low flow or if the water level drops. This can be seen in the diagrammatic representation of a drinking water system in Figure 6.

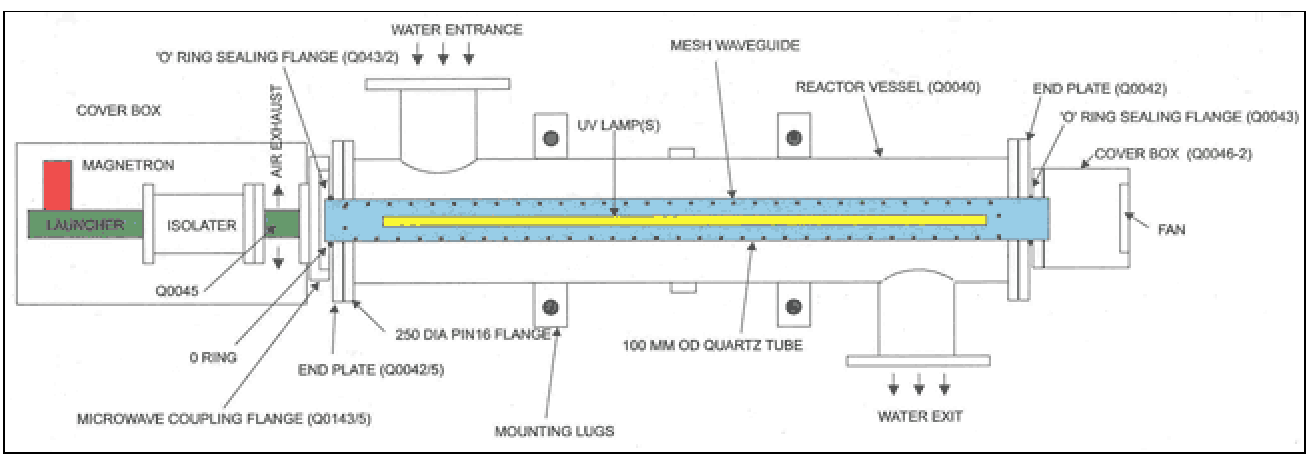
There is no limit to the number of times that the lamp can be turned on and off per day and the system has instant re-strike capability without the need for a 'warm-up' period. Also the efficiency of the lamp at converting electrical energy into UV light is the same on Day 1 as it is on Day 900 with no decrease in the UVC output.

Figure 5 Typical UV Module

The primary advantages of this type of UV system are the savings in operational and maintenance costs. Lamp replacement costs and savings in the time associated with changing bulbs results in significantly lower whole of life costs.

The technology was developed by Quay Technologies and was recently acquired (June 2007) by Severn Trent Services Ltd. There are systems currently installed in 10 countries worldwide treating both drinking water and wastewater. One of the first systems of this type to be installed in Ireland was at the Dunbeg wastewater treatment plant, County Clare.

Figure 6 Diagrammatic Representation of Closed Chamber Drinking Water Treatment System



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