6.6.2 UV Disinfection Process Control

The UV disinfection system receives flow from the MBR permeate pumps. The NPDES permit requires that the plant effluent meet a disinfection standard of 126 e. coli organisms/100 ml on a monthly geometric mean. The UV disinfection system provides a secondary barrier beyond the membrane filtration process.

UV DISINFECTION BACKGROUND

Ultraviolet (UV) disinfection is used as a means of wastewater disinfection. Unlike other disinfection technologies UV treatment does not require the addition of chemicals to the water. Additionally, the use of UV irradiation does not result in the formation of toxic by-products such as Trihalomethane (THM), Haloacetic Acids (HAA5) or Bromides. This process does not alter the water other than inactivating microorganisms. UV radiation is light energy between 100 and 400nm wavelength, between the X-ray portion of the spectrum and the visible portion. Therefore, UV light is not visible to the naked eye. As ***Figure 6.6.2-1*** shows, the spectral curve of UV radiation absorption by living microorganisms such as cells peaks at 260nm near the 253.7nm wavelength generated by mercury discharge low-pressure lamps.

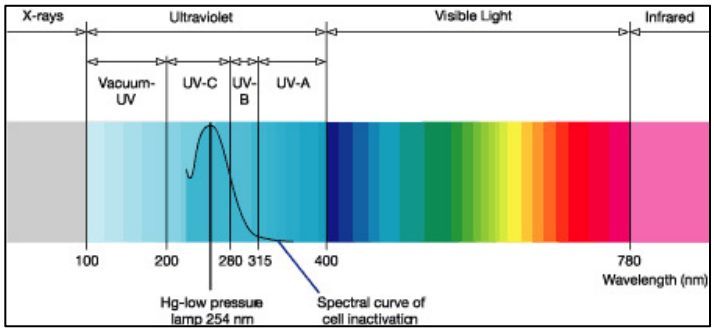

Figure 6.6.2-1. Light Spectrum

UV light is absorbed by proteins, RNA and DNA in a given microorganism. DNA is a nucleic acid polymer in a double-stranded helix linked together by a sequence of four constituent bases (adenine, cytosine, guanine and thymine), which constitute the microorganism genetic code. These form “base pairs” (adenine with thymine and cytosine with guanine) held together by hydrogen bonds. Of these four bases, thymine undergoes a unique photochemical reaction in the presence of UV radiation. Thymine bases are located adjacent to each other and absorption of a UV photon by one of the thymine leads to formation of a chemical bond between the two adjacent thymine bases, called a thymine dimmer. This photochemical reaction is illustrated in ***Figure 6.6.2-2*** below.

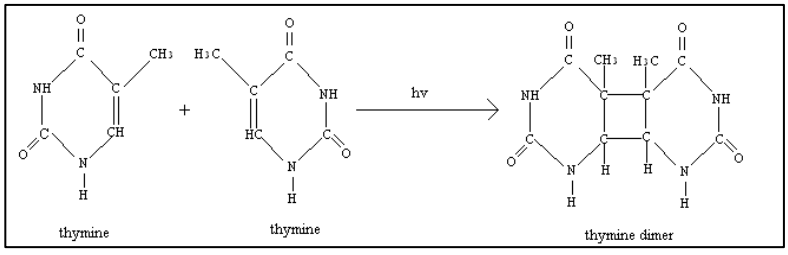

Figure 6.6.2-2 - Photochemical Dimerization of Adjacent Thymine Bases

The photochemical dimerization of thymine pairs disrupts the structure of the DNA preventing its normal replication in cell mitosis. As a result the microorganism becomes incapable to multiply and looses its infectivity. This is the fundamental mechanism of UV disinfection. UV disinfection implies the use of the ultraviolet portion of the electromagnetic (EM) spectrum to inactivate microorganisms. UV is capable of inactivating pathogens such as bacteria, viruses,

UV DOSE

The UV dose is defined as the quantity of germicidal UV energy per unit of specific area (mJ/cm_2). In simplest terms the UV dose is a function of UV irradiance (mW/cm_2) and contact time (seconds) and can be expressed as follows,

$$UV\ Dose\ (mJ/cm_2) = UV\ Irradiance\ (mW/cm_2) \times Time\ (sec)$$

The UV dose cannot be measured directly. However, both the UV irradiance and time can be accurately determined. The UV irradiance varies in direct proportion to the water UV absorbance, which indicates its UV demand, a term similar to chlorine demand. In North America the term UV transmittance is used to qualify the UV demand of a water rather than UV absorbance. The relationship between the two parameters derives from the Beer Lambert law and can be stated as follows,

$$UVT(\%) = 100 \times 10^{-A(lm)}$$

With

UVT: UV Transmittance

A: UV absorbance

The UV transmittance is typically measured through a 1-cm thick layer of water and is equal to the ratio of transmitted irradiance to incident irradiance. Measurement is performed directly on water samples without any pretreatment using a spectrophotometer set at a 253.7 nm wavelength. The source of UV irradiance within a UV disinfection system comes from mercury discharge low-pressure lamps or UV lamps arranged vertically in the flowing stream of water. The flow rate determines how much time the microorganisms are exposed to the UV irradiance field produced by the lamps.

Changing either the water UV transmittance or the flow rate will significantly affect the UV dose and therefore the microbial quality of the wastewater discharged from the UV system. For example, if the water flows by the UV lamps too quickly, even with high UV transmittance water, disinfection may be incomplete. Alternatively, if the water has a low UV transmittance, even at low flow rates, the disinfection may be considerably reduced.

The UV system described in these instructions will disinfect water to meet the requirements of the operation standards or discharge permit. The UV system installed

has been engineered to both operate at specific flow rates and treat the wastewater that is characteristics of this particular installation.

IMPACT OF WATER QUALITY

UV TRANSMITTANCE

Certain chemicals like proteins, phenols, humic materials, lignin sulfonates and iron when dissolved in the water will absorb UV energy before it can reach the target microorganisms. Since dissolved chemicals may not be visually evident water may appear clear and have a very low UV Transmittance. The UV Transmittance of a water can be accurately determined with a spectrophotometer. The system was designed with a conservative UV Transmittance of 65%.

SUSPENDED SOLIDS

Suspended solids are also a major factor affecting the transmission of UV light to a target microorganism. Since particles in water stop, absorb and dissipate UV light any microorganisms attached to those particles will not be exposed to the full extent of a UV disinfection system irradiation field. The MBR effluent is very consist in producing low turbidity waters. Therefore, suspended solids or turbidity should not be a variable in the Tri-City WPCP.

QUARTZ SLEEVE FOULING

The quartz sleeves are designed to insulate the UV lamps from the water ensuring optimum operation at the correct temperature. Fused quartz is used to fabricate the sleeves to allow greater transmission of UV light as compared to glass or plastic. During regular use, the quartz sleeves will become coated with both organic and mineral materials that reduce the transmission of UV light through the quartz. The amount of fouling and the rate at which it develops depends on the characteristics of the wastewater and is therefore site specific.

The coating or fouling can be removed from the sleeves using three methods as follows.

- Repetitive mechanical wiping / cleaning of the sleeves with or without the use of an in-channel air scour.
- Manual hand scrub using Scotch-Brite™ pads and an ammonia based detergent.
- Soaking of the module or bank inside a chemical cleaning station located adjacent to the channels.

All these methods can be used together or separately to achieve the desired cleaning effect on the quartz sleeves.

UV DISINFECTION DISCHARGE LIMITS

The effluent for the Tri-City WPCP effluents is required to meet specific disinfection requirements for e-coli prior to river discharge.