



PROCESS DESCRIPTION

PRINCIPLES OF THE MULTI-STAGE FILTRATION PROCESS

The **Multi-Stage Filtration** process effectively treats raw water with a wide range of quality to high standards without the use of pre-treatment chemicals or complex filter backwash procedures. The process is designed for small systems ranging from 20 to 2,000 in population. The fundamental design principle is for operational simplicity.

The **Multi-Stage Filtration** process is based on the principles of slow sand filtration. Slow sand filtration is a proven treatment process which has been gaining popularity for small systems due to its inherent simplicity of operation. Typical 'conventional' slow sand filter designs, however, are limited in application to good quality raw water sources. In the past this has precluded its use in many smaller communities which could benefit most from its operational simplicity. The **Multi-Stage Filter** process overcomes these limitations while retaining the passive simplicity of the slow sand filter operation and produces water of exceptionally consistent quality that meets or exceeds regulatory requirements.

The Multi-Stage Filtration Process consists of the following unit operations:

1. Pre-Ozonation (If Required)
2. Roughing Filter
3. Slow Sand Filter

Ozonation oxidizes organic molecules such as colour, taste and odour compounds, and generally reduces the organic loading of waters and therefore reduces precursors to disinfection by-products. Ozone addition prior to slow sand filtration can increase the efficiency of TOC removal by about 35 percent (EPA Guidance Manual, Alternative Disinfectants and Oxidants, April 1999). Currently operating MS Filter systems with pre-ozonation are removing colour from as high as 120 TCU to less than 5 TCU without the need for a GAC contactor. Ozonation is also effective at removing iron and manganese and as an aid to coagulation.

Ozone is also an effective disinfectant for bacteria, viruses and especially chlorine resistant cysts such as giardia and cryptosporidium. Research on cryptosporidium and giardia removal by slow sand filtration has shown greater than 99.99% (4 log) removal. With the optional ozonation stage, the system is capable of achieving greater than 99.999% (5 log) removal/inactivation of cryptosporidium and giardia. Currently the Ontario Ministry of the Environment gives the Multi-Stage Filter, excluding the ozone stage, 2.5 log credit for giardia, similar to most other filtration technologies. The minimum 3.0 log inactivation is achieved with post disinfection or by using the disinfection credit from the pre-ozone. Regardless of the technology, the regulations require a minimum 0.5 log inactivation of giardia from disinfection.

The roughing filter consists of a coarse gravel base progressing upwards to a coarse sand intermediate layer, topped by a granular activated carbon (GAC) cap. The primary purpose of the roughing filter is to protect the slow sand filter from excessive solids loading or residual disinfectants such as chlorine or ozone. Larger solids and large biological organisms such as algae are strained out of the raw water in the roughing filter. The roughing filter removes up to 80% of suspended solids. The GAC cap has three important filtration functions; 1) the GAC acts as a physical strainer for coarse materials, 2) the GAC is an excellent support media for biological materials and will itself become a biological pre-filter, 3) the GAC will chemically reduce any oxidants in the water such as residual ozone or chlorine from an upstream zebra mussel control step.

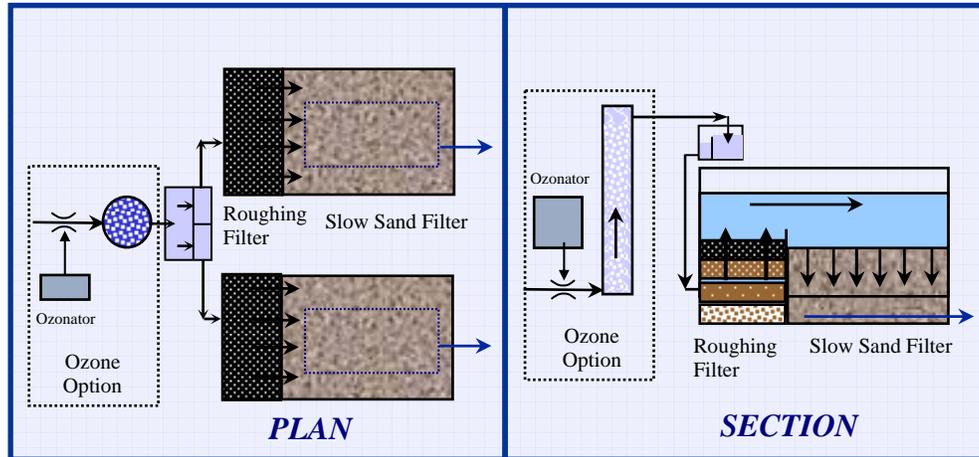
The slow sand filter is the core of the Multi-Stage Filter. The slow sand filter consists of a large bed of fine sand, typically 600 mm deep, supported by beds of progressively coarser sand and gravel surrounding an underdrain system. Slow sand filtration has been used for over 150 years as an effective means of filtering water and controlling microbiological contaminants. No chemical pre-treatment is used to remove turbidity in slow sand filters. Instead, the water is filtered at slow filtration rates and a biological layer is developed at the surface of the sand. Instead of chemical coagulants and polymers, natural polymers formed by biological material in the filters act to remove turbidity. Three processes are at work in the biological filter to remove turbidity and microbial contaminants; 1) physical straining of particles caught in interstitial pores, 2) adsorption of charged particles onto natural biological polymeric material, and 3) biological digestion as larger organism prey upon smaller ones and other organic matter in the water.

Slow sand filters excel at removal of microorganisms. Greater than 4-log (99.99%) removal of giardia cysts has been demonstrated by researchers. Slow sand filtration alone has been given a 2-log giardia removal credit by most regulatory bodies. In Ontario, the combination of a roughing filter and a slow sand filter has been given 2.5 log giardia removal credit. In most jurisdictions, pre-ozonation can be applied for up to 2.0 log additional disinfection credits.

Advantages of the Multi-Stage Filter

- Ease of operation
- No pre-treatment chemicals and no large chemical storage and feed areas
- Lower operating cost, lower life cycle cost
- Meets government guideline for filtration of surface waters
- Effective treatment for turbidity, cysts, bacteria, and colour
- Simple cleaning techniques produce very little waste
- Effective for a wide range of raw water quality
- Pre-fabricated unit minimizes concrete and reduces construction time

Figure 1. - Components of The Multi-Stage Filtration Process



Pre-Ozonation (If Required)	Roughing Filter	Slow Sand Filter
<p>The pre-ozonation serves two very important functions. As a disinfectant and as an oxidant for dissolved organics. It breaks down the organics into a more biodegradable form that is readily removed by the slow sand filter. The ozone system is robust and modular in construction for ease of service</p>	<p>The roughing filter removes up to 80% of the raw water turbidity. This process is suitable for sources high in turbidity and algae. A layer of GAC is included to augment the biological filtration and protect the slow sand filter from disinfection chemicals i.e. chlorine or ozone.</p>	<p>The slow sand filter provides excellent turbidity removal. This is a biologically active process which provides good removal of dissolved organics and excellent removal of Giardia and Cryptosporidium.</p>



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