Distillation is the collection of vapor produced by a boiling liquid and returning it to liquid state (condensing) by cooling. This change of state process is used to purify of water since most contaminants do not vaporize and therefore do not pass to the distillate upon condensation.

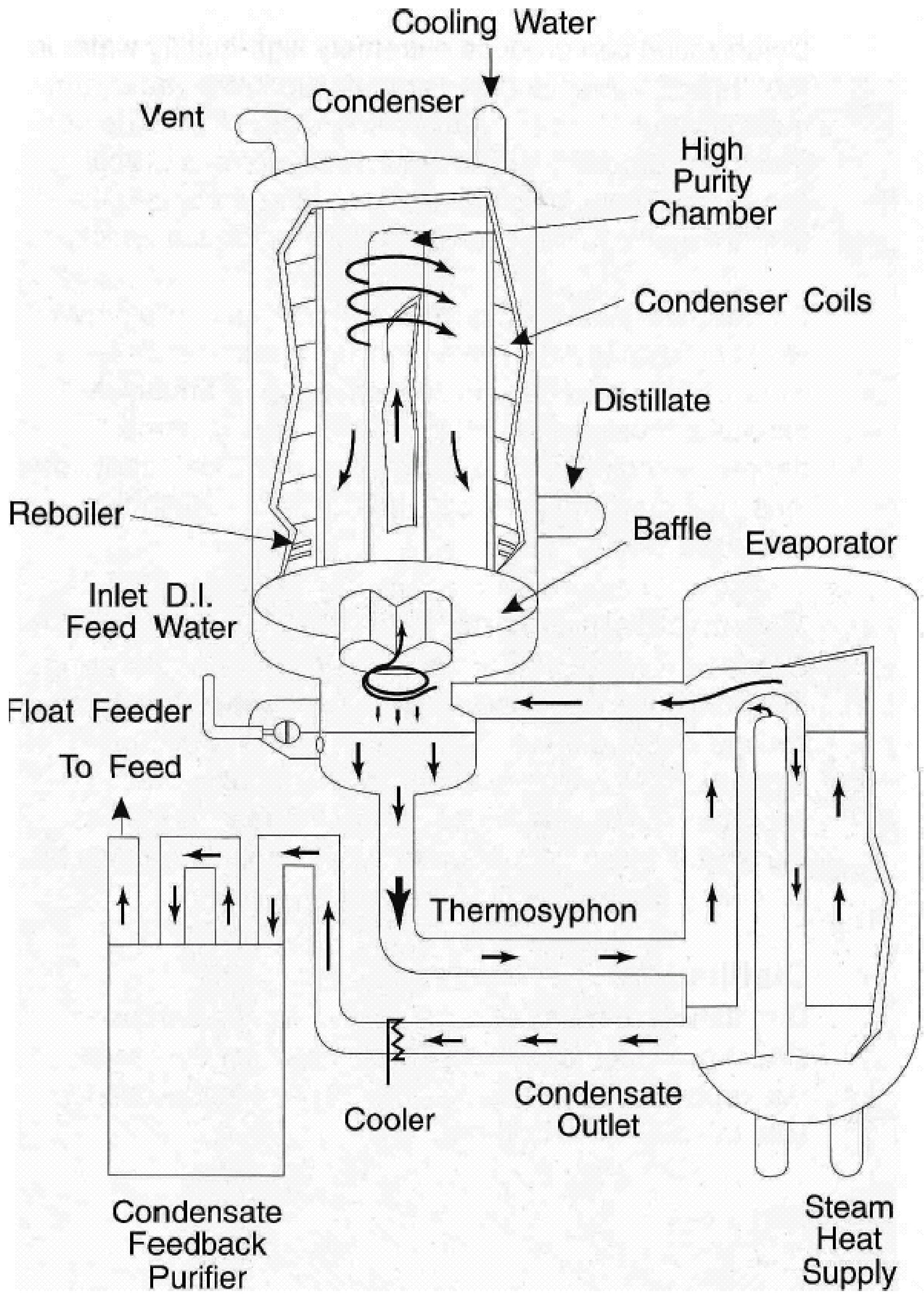

Figure 20 - Distillation Process *(Courtesy of Vaponics, Inc.)*

A well designed **still** can remove both organic and inorganic contaminants, including biological impurities and pyrogens. Distillation involves a phase change, which removes impurities down to the range of 10 parts per trillion, producing water of extreme high purity. The most common use of stills today is in laboratory, biotechnology and pharmaceutical industries because of their critical concern for biological contamination.

Distillation is the only technology that can consistently supply pyrogen-free water without the use of chemicals. Distillation is relatively energy intensive. Precise temperature monitoring is required to ensure purity and to avoid contamination of the purified water. Organic materials with a boiling point near that of water are very difficult to remove, due to carry over into the vapor. In these situations a double distillation system is often required for complete pyrogen removal.

Reverse osmosis (RO) or **ultra-filtration (UF**) are commonly used pretreatment to provide feed water for the distillation systems. This additional, and costly, step is to prevent damage caused stills by scaling and organic contamination. In most cases the RO system removes all the pyrogens and the still acts as a back-up system for **water-for-injection (WFI)** water.

Controlling microorganism colonies is important in maintaining the performance of all water systems, especially ultra-pure systems where bacterial fouling is the leading cause of contamination. Regularly monitored bacterial control equipment is a necessity.

Disinfection may occur on a continuous or a periodic (shock) basis. Continuous disinfection is preferable to keep bacterial populations from reestablishing themselves. Shock treatments are used when continuous biocide would be harmful to the end user. In shock treatment, the biocide and its by-products are flushed from the system prior to re-start.

Shock treatments generally remove a bacteria population but do not prevent it from recurring. Two important considerations when using biocides are 1) concentration and 2) dwell time. The higher the concentration, the shorter the dwell time needed for effective disinfection.

Other factors that affect biocide effectiveness are pH, temperature, water hardness, chemical compatibility and cleanliness issues. Most systems require cleaning before disinfection. Cleaning removes most surface bacterial film but they quickly re-establish themselves (see Disinfection).