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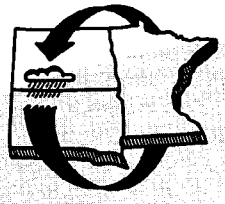


Treatment Systems for Household Water Supplies: Distillation

by Russell Derickson, Fred Bergsrud, and Bruce Seelig

What impurities will distillers remove?

The distillation process removes almost all impurities from water. Distillers are commonly used for removing nitrate, bacteria, sodium, hardness (dissolved solids), most organic compounds, heavy metals and radionucleides from water. Distillers remove about 99.5% of the impurities from the original water.

What impurities are not removed?

Distillers can allow 0.3% to 0.5% of water impurities to exist in the storage container after distilling.

Some volatile organic contaminants (VOCs), which include certain pesticides and volatile solvents, boil at temperatures very close to the boiling point of water (207-218°F) so these types of contaminants will not be substantially reduced in concentration. However, properly equipped distillers can reduce VOC concentrations effectively. (See "How Are Volatile Organic Compounds Removed" on page 2).

Also bacteria can accumulate in a distiller's cooling coils when the distiller has not been used for a period of time.

What are the advantages of distillers?

Distillers remove almost all of the impurities found in water, produce sodium-free water if needed for health reasons, and are relatively easy to maintain. Most distillers are mechanically simple.

What are the disadvantages of distillers?

Distillers have small capacities and use considerable energy to process water. Because of the small capacities, distillers are limited to point-of-use systems. Distillers without gas vents, fractional columns or ACF units may not remove compounds (volatile liquids) that have boiling temperatures close to water. Heat generated by a distiller must be dissipated into the surrounding environment.

How to test your water

Before you buy any water treatment unit you should know what impurities are found in your water supply. To determine the types and amounts of impurities in your water you should have it tested/analyzed by a certified lab. The results of the water test will help determine the best water treatment system to use.

If you obtain water from a private water supply (you supply your own water), you are responsible for water testing. These tests should be done on a regular basis. If you suspect a problem, test the water more often.

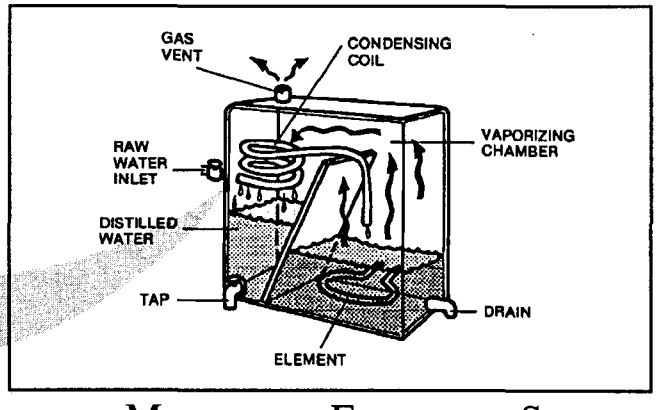
Community water supplies are monitored and treated to protect users from health-threatening water impurities. Ask your water supplier for a copy of the latest water test results.

How the distillation process works

Distillers use heat to boil water into steam which is condensed back into water and collected in a more pure form. When water boils, it leaves impurities behind in the boiling chamber. The rising steam passes into a cooling section and condenses back into a liquid. The condensed liquid (water) then flows into a storage container (see Figure 1). As water is heated, the impurities in the boiling chamber increase in concentration. The water left behind in the boiling chamber is discarded and the process is started over.

Distillers remove almost all of the impurities from water supplies used for drinking purposes in North and South Dakota, and in Minnesota. Distilled water has a bland taste because the dissolved minerals that give water a pleasing taste have been removed. Distilled water should be stored

Figure 1. How the Distillation Process Works



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under sanitary conditions in plastic, glass or stainless steel containers.

Household distillers are designed for providing water for drinking and cooking. It is not necessary to distill water for other uses like flushing toilets, bathing, washing clothes and cleaning.

Figure 2. Batch Distiller Unit

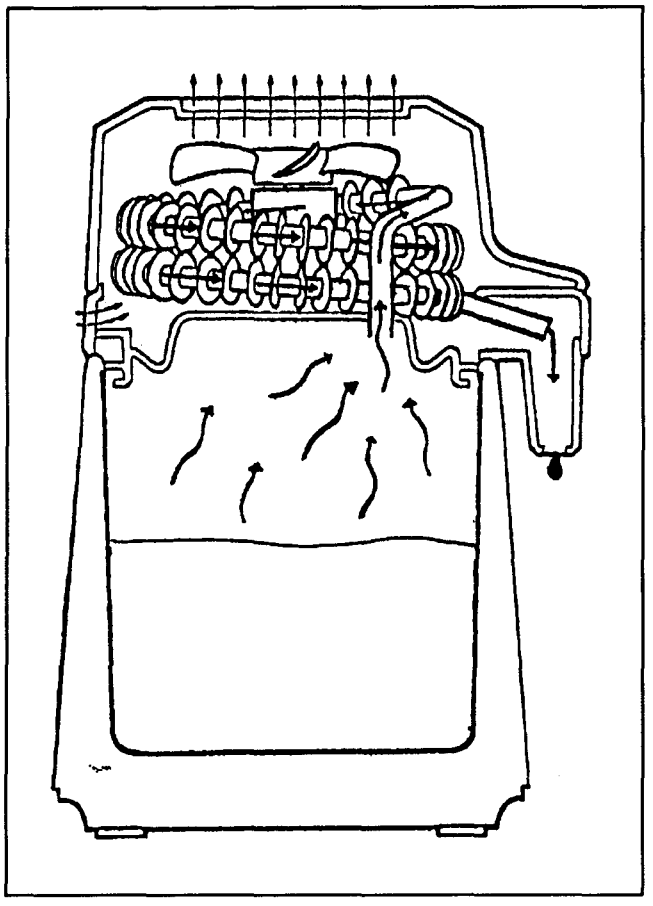
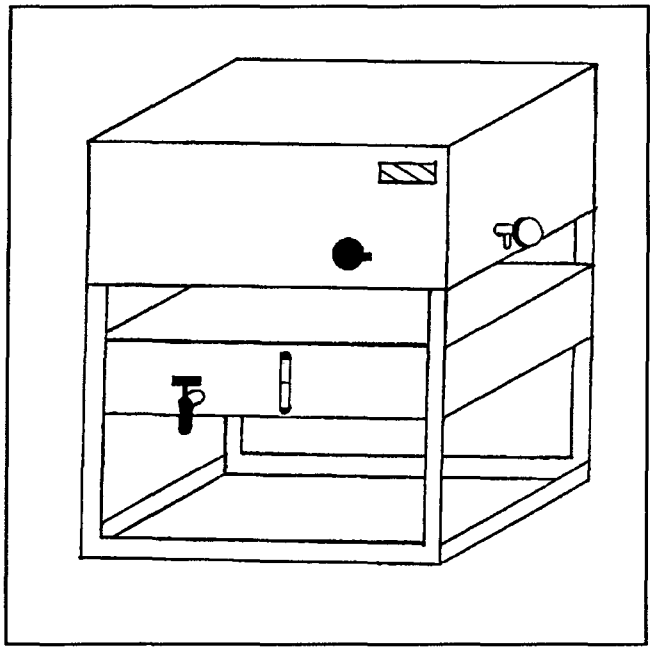


Figure 3. Continuous Flow Distiller Unit



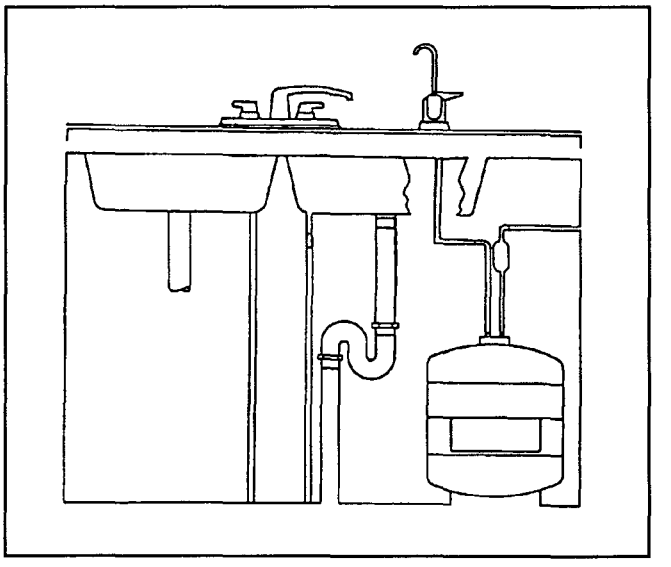
What types of distillation equipment are available?

Distillers are commonly made of stainless steel, aluminum and plastic materials. These materials do not absorb impurities from water and are easy to clean.

There are two types of distillers: batch units and continuous flow units (see Figures 2 and 3).

1. **Batch Distillers:** Water is poured directly into the boiling chamber. The unit is turned on and the water is heated to boiling. When all the water in the boiling chamber is evaporated, the unit shuts off. Distilled water is removed from the storage container for household use. Batch units can range from 1 gallon counter-top units to 10 gallon floor units. Batch distillers produce from 3 to 10 gallons of distilled water per day. The smallest distillers are about the same size as a coffee maker.
2. **Continuous Flow Units:** Continuous flow or automatic units are connected to the water supply line. The water level in the boiling chamber is maintained by a float valve connected to the water supply. As distilled water is removed from the storage tank, the unit turns itself on and starts producing more distilled water. A discharge line periodically removes the concentrated impurities from the boiling chamber. Distilled water is either stored in a container or is piped to the use area.

Figure 4. Under-the-sink Reserve Tank



Distiller accessories might include additional storage containers, transfer pumps and special kitchen taps that can be installed adjacent to a distiller. Increased storage capacity will be advantageous only for continuous flow units. For example, you can install a kitchen tap and an under-the-sink reserve tank that has a level switch to turn on a small transfer pump. This pump transfers water from the distiller to a storage container located under the sink (see Figure 4). When the under-the-sink reserve tank empties it turns on the transfer pump to refill the reserve tank. When the distiller's storage tank empties, it turns itself on and fills the storage containers. Capacity is increased by increasing the total amount of distilled water available to the user.

How are volatile organic compounds (VOCs) removed?

Distillers can remove VOCs by three methods: gas vents; fractional columns; and activated carbon filters (ACF). Distillers that use a combination of VOC removal methods are more efficient than those using one single method.

1. **Gas Vents:** Gas vents are small holes drilled into the passage leading to the cooling coils. Gas vents allow VOCs to escape the distiller before they enter the cooling section coils. These holes (one or two) are usually from .045 inches to .065 inches in diameter.
2. **Fractional Column Distillers:** This method uses differential cooling to remove VOCs. VOCs are removed when they condense in a different section of the fractional column than where water does. Fractional distillers usually cost more than distillers with gas vents or ACF cartridges.
3. **Activated Carbon Filters (ACFs):** ACFs trap VOCs in millions of small pores. ACFs need periodic replacement. The life span of an ACF is dependent on the concentration of VOCs in the water. ACF units, normally located at the end of the cooling coils, remove the VOCs prior to entering the distilled water storage container. ACFs can also be placed in the water supply line to reduce VOCs entering a distiller.

Removal of VOCs in distillers without gas vents, fractional columns or ACFs can also be accomplished with some success by discarding the first pint (liter) of distilled water in the storage container.

How To Maintain Distillation Equipment

Minerals and other residues accumulate in the boiling chamber as water is boiled away. These minerals and compounds need to be removed occasionally. The boiling chamber of a distiller should be emptied about once a week. If used constantly, the boiling chamber must be emptied more often. If these materials (scale and sediment) are not removed periodically, a distiller becomes inefficient. Mineral scale buildup from hard water can be difficult to remove without the use of an acid-type cleaner.

Commercial cleaning agents are available to remove the scale buildup in distillers. The cleaners usually contain sulfamic acid or other organic acids. DO NOT use strong mineral acids like hydrochloric, sulfuric, nitric, etc. to clean distillers. These strong mineral acids tarnish and can damage stainless steel and aluminum. Check the owners manual or consult your local distiller dealer for the appropriate cleaner to use.

To remove the scale buildup from a distiller, mix an acid cleaner to the correct concentration as indicated by the cleaner's label. Fill the distiller with the acid mix to approximately 1/2 inch above the mineral line. Let the organic acid solution sit for the length of time indicated on the label.

Vinegar is an alternative cleaning agent because it contains acetic acid, a weak organic acid. Pour a 50% solution of vinegar into the distiller to about 1/2 inch above the top of the mineral line and let the unit sit overnight. Then empty the distiller and rinse with water. If mineral scale is still present, increase the vinegar concentration or cleaning time.

Replace the ACF cartridge (if equipped) as needed or make sure the gas vent holes are free of mineral deposits. Routine maintenance and cleaning will increase the life span of a distiller. The life span of any distiller depends on the levels of impurities in the raw water supply, how often the distiller operates and how often the distiller is cleaned. A good distiller should last 10 to 15 years with proper maintenance and routine cleaning. The most common repair for distillers is replacing a heating element or a cooling fan.

What are the costs of distillation equipment and operation?

Equipment Purchase Price

Distillers cost from $200 to $1500 for home use models. Counter top distillers will range from $200 to $500, and automatic models from $600 to $1500. In addition to the purchase cost there are yearly operation costs. These include electricity, chemical cleaners and replacement ACF units if equipped. Yearly operation costs are dependent on how often a distiller is used.

Examples of Purchase Cost:

For about $250, you can purchase a 5 quart batch unit (about the same size as a coffee maker). Five quarts of raw water are poured into the boiling chamber. The unit is plugged in and the distillation process starts. Distilled water is stored in an external plastic container. The unit shuts off automatically when the boiling chamber is empty. It has a maximum output of 4 gallons per day.

For about $1200, you can purchase a 10 gallon per day continuous flow unit with a 4 gallon storage container. When water is removed from the storage container, the unit refills the boiling chamber and begins distilling. The unit shuts off when the storage container is filled. Typical dimensions of this system are about 3 feet high x 2 feet wide and 1.5 feet deep.

Operation costs

Distiller operation costs are directly related to the amount of distilled water you will use daily. The largest operation cost is electricity. Small batch distillers range from .25 to .30 gallons per Kilowatt-hour (gal/KWH); and larger automatic continuous flow distillers range from .30 to .34 (gal/KWH).

The electrical cost is easy to calculate:

$$\text{Cost} = 0.024 \times \text{Production (Gal/Day)} \times \frac{\text{Wattage of Unit}}{} \times \text{Cost of Electricity}$$

-or-

$$\text{Cost (\$/KWH)} = \frac{\text{Wattage of Unit} \times \text{Time to Distill 1 Gal (Hours)} \times \text{Cost of Electricity}}{1000}$$

For Example:
A 1100 watt distiller produces 8 Gal/Day (3 Hr/Gal) and the electricity cost is $0.10/KWH, so

$$\text{Cost} = 0.024 \times \frac{1100}{8} \times 0.10 = \$0.33/\text{Gal or (33 Cents/Gal)}$$

-or-

$$\text{Cost} = \frac{1100}{1000} \times 3 \times 0.10 = \$0.33/\text{Gal}$$

Typical electrical costs for a family of four will range from $275 to $400 per year (or $22 to $34 per month) because

the average family of four uses 3 gal/day (1100 gal/year) of water for drinking and cooking.

Consult the owners manual or check with a dealer for the cost of an ACF cartridge replacement for a particular distiller. The cost of cleaning increases with increased distiller operation.

Total cost over the life span of a distiller

The total cost of running a distiller includes the purchase price (or rental cost/year), cost of operation (electricity and ACF if used) and maintenance cost. Typical operational costs range from $0.35 per gal to $0.50 per gallon. Bottled distilled water, in comparison, costs from $0.30 to $1.50.

Based on the example below, it will cost an average family of four $38.60 per month for distilled water or $456.50 per year.

Example of Total Cost of Distilled Water Per Gallon: Let's assume that, for $800 you could purchase a 1100 watt distiller that would last 10 years at full production of 8 gal/day and electricity costs $0.10/KWH. How much will a gallon of distilled water cost?

Cost Assumptions:
Electricity = $0.10 / KWH
Repairs and Cleaning = 10% of Purchase Price/Year
10-Year Life Span
1100 Watt Unit Produces 8 Gal/Day
Purchase Price = $800

Total Cost Per Gallon Over Ten Years:
Purchase Price
$800/8 (Gal/Day)/365 (Days/Year)/10 Years = $0.027/gal (Based On Continuous Operation)
Electricity
1100wt/1000 (wt/KWH) X 3 (hr/gal) X $0.10KWH = $0.33/Gal
Repairs and Cleaning
$800 X 0.10/8 (Gal/Day)/365 (Days/Year) (Annual Cost = 10% of Purchase Price) = $0.027/Gal

TOTAL $0.384/Gal (38.4 Cents/Gal)

A typical distiller might realistically only run 60 to 70 percent of the time. The above total cost per gallon was figured at full production. If the distiller ran 70% of the time the cost per gallon would increase by $0.0314/gallon for a total of $0.415/gallon. The distiller idle time varies with how much distilled water is needed by the user. Based on the example above, it will cost a typical family of four $38.60 per month ($456.50 per year) for distilled water.

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What to consider when purchasing a distiller

- Test your water for impurities. A distiller might not be the best treatment alternative.

Determine the following:

- How much distilled water does your household need (per day, per year)?
- What type of distiller will fit your needs?
- What level of convenience should a distiller offer (manual or automatic operation)?
- What will you do with the by-products of distillers (waste water, waste heat, old ACF cartridges)?
- Is the distiller designed to remove VOCs? (Distillers should be operated with activated carbon filters if volatile organic compounds are present.)
- What is the cost of replacement parts and ACF cartridges (if equipped)?

Additional Recommendations:

- Investigate equipment before purchasing or renting. Don't rush a purchase.
- Know that the purchase price does not directly indicate the quality of a distiller's performance. A moderately-priced unit might work as well as an expensive unit. Consider convenience as well as performance.
- Don't buy more equipment than you need.
- Choose a reputable dealer. Get guarantees in writing and read them thoroughly.
- Beware of advertising that is too good to be true.
- Equipment should carry UL and NSF or AWQA approval.

Who to contact for further information

For further information contact your local county Extension Office or state health department. Additional information can be found in other publications in this series:

Treatment Systems For Household Water Supplies:

- Activated Carbon Filtration
- Chlorination
- Iron and Manganese Removal
- Reverse Osmosis
- Softening

References

MWPS-14	*Private Water Systems,* Midwest Plan Service
HE-430	*Household Water Treatment,* NDSU Extension
FS-5	*Drinking Water: Treatment Guidelines,* University of Maryland Extension
	Water Treatment Handbook, Rodale Testing
9.729	*Drinking Water Treatment Devices: Distillers,* Colorado State Extension

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