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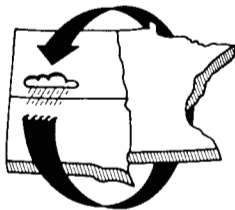
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Treatment Systems for Household Water Supplies

Distillation



by Russell Derickson, SDSU Extension associate in water & natural resources; Bruce Seelig, NDSU water quality specialist, North Dakota Extension Service; and Fred Bergsrud, UM Extension agricultural engineer and water quality coordinator, Minnesota Extension Service

What Impurities Will Distillers Remove?

Distillation removes about 99.5% of impurities from water. Distillers commonly are used for removing nitrate, bacteria, sodium, hardness (dissolved solids), most organic compounds, heavy metals, and radionuclides from water.

What Impurities Will Distillers Not Remove?

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

Some volatile organic contaminants (VOCs)(certain pesticides and volatile solvents) boil at temperatures very close to water (207-218°F.) so these types of contaminants will not be substantially reduced in concentration. Properly equipped distillers can reduce VOC concentrations effectively. Bacteria can accumulate in a distiller's cooling coils when it has been inactive.

Water Testing

Before you buy any water treatment unit, find out the types and amounts of impurities in your water supply. Have the water 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. Test on a regular basis. If a problem is suspected, 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.

The Distillation Process

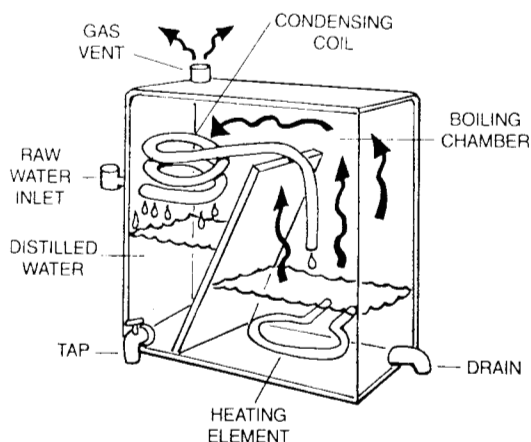
Distillers use heat to boil water into steam which is condensed back into water and collected in a purer form. When water boils, it leaves impurities behind in the boiling chamber. The rising steam passes into a cooling section and condenses back into a liquid. The condensed liquid (water) then flows into a storage container (Figure 1).

Distillers remove almost all of the impurities from water supplies used for drinking purposes in the Dakotas and Minnesota. 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.

Distilled water has a bland taste because the dissolved minerals that give water a pleasing taste have been removed. Store distilled water under sanitary conditions in plastic, glass, or stainless steel containers.

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

Figure 1. Distillers boil water into steam and condense it back into purer water.



Types of Distillation Equipment

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

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

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.

Continuous flow units: This is an automatic units 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 to produce 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.

Distiller accessories: Additional storage containers, transfer pumps and special kitchen taps can be installed adjacent to a distiller. Increased storage capacity only will be an advantage for continuous flow units.

Figure 2. Batch distiller.

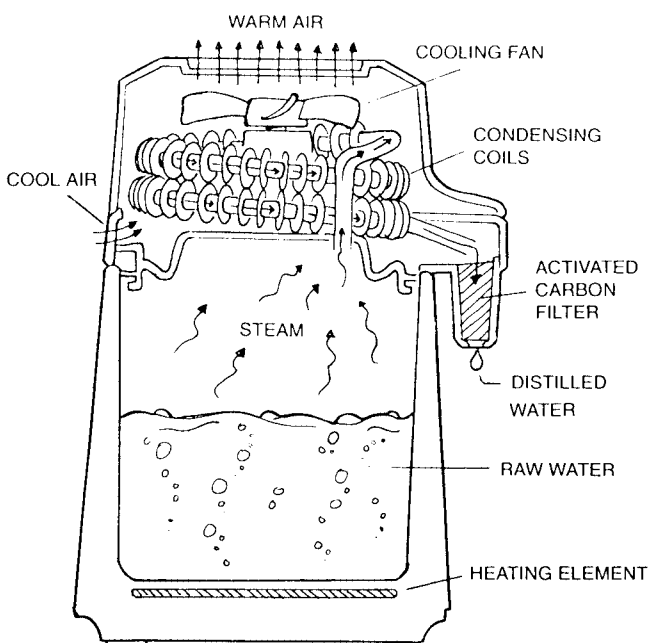


Figure 3. Continuous-flow distiller.

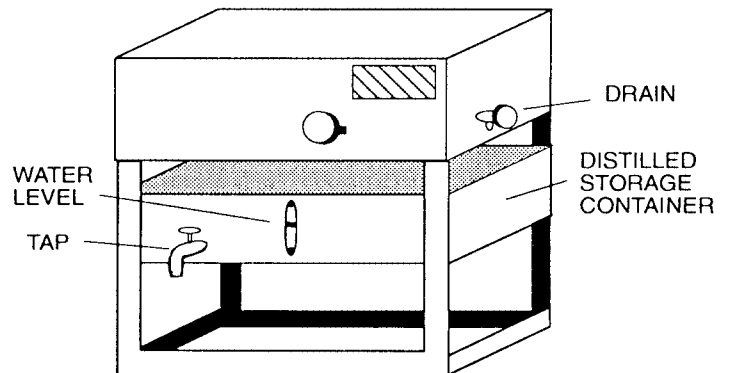
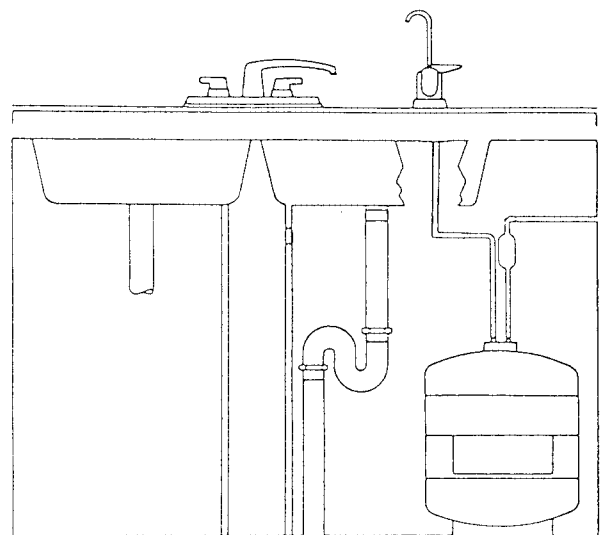


Figure 4. Under-the-sink distiller.

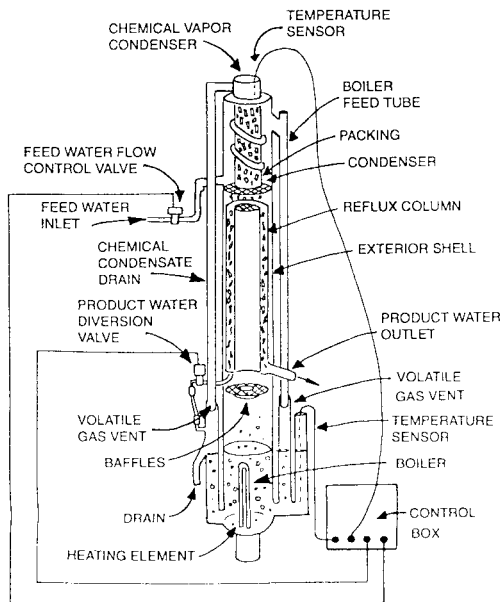


For example, you can install an under-the-sink reserve tank that has a level switch to turn on a small transfer pump (Figure 4). This pump transfers water from the distiller to a storage container located under the sink. When the under-the-sink reserve tank empties, it turns on the transfer pump to refill 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 (VOC) 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 a single method.

Figure 5. Fractional column distiller.



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.

Fractional column distillers use differential cooling to remove VOCs (Figure 5). 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.

Activated carbon filters (ACF) trap VOCs in millions of small pores. ACFs need periodic replacement. The life span of an ACF depends on the concentration of VOCs in the water. The ACF units normally are located at the end of the cooling coils and remove the VOCs prior to entering the distilled water storage container. ACF's also can be placed in the water supply line to reduce VOC's entering a distiller.

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

Proper Distiller Maintenance

Minerals and other residues accumulate in the distiller's boiling chamber as water is boiled away. These minerals and compounds need to be removed occasionally. Empty the boiling chamber about once a week. If used constantly, empty the boiling chamber more often. If 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 indicated labeled time.

An alternative cleaning agent is vinegar 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 over night. Empty the distiller and rinse with water. If mineral scale is still present, increase the vinegar concentration and/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 lifespan of a distiller.

The lifespan of any distiller depends on the levels of impurities in the raw water supply, how often the distillers 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.

Cost of Distillation Equipment

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.

Examples of purchase cost:

For under \$200, 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 distillation begins. Distilled water is stored in an external plastic container. The unit shuts

off automatically when the boiling chamber is empty. It has a 4-gallon per day maximum output.

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 x 1.5 feet deep.

Operation Costs

In addition to the purchase cost of the distiller, there are yearly operating costs. These include electricity, chemical cleaners, and replacement ACF units (if equipped).

Yearly operation costs depend on how often a distiller is used. 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:

$$\text{Cost} = 0.024 \times \frac{\text{Wattage of unit}}{\text{Production (gal/day)}} \times \text{cost of electricity (\$/KWH)}$$

or

$$\text{Cost} = \frac{\text{Wattage of unit}}{1000} \times \text{time to distill 1 gal (hrs)} \times \text{Cost of electricity (\$/KWH)}$$

For example, a 1100 watt distiller produces 8 gal/day (3hr/gal) and electricity costs \$0.10/KWH

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

-or-

$$\text{cost} = \frac{1100}{1000} \times 3 \times 0.10 = \$0.33/\text{gal}$$

Typical electrical cost 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 a ACF cartridge replacement for a particular distiller.

Cleaning cost increases with increased distiller operation.

Total Cost Over the Life Span of a Distiller

Total cost of running a distiller includes the purchase price (or rental cost/year), cost of operation (electricity & 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:

For \$800, you could purchase a 1100-watt distiller that would last 10 years at full production of 8 gal/day. Electricity costs \$0.10/KWH. How much will a gallon of distilled water cost?

Cost assumptions --

- electricity = \$0.10 / KWH
- repairs & 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(based on continuous operation) = \$0.027/gal
- 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 per gallon for a total of \$0.415/gal. 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 \$38.60 per month (\$456.50 per year) for distilled water.

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.

Disadvantages of Distillers

Distillers have small capacities and use considerable energy to process water. Because of their 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.

Considerations When Purchasing a Distiller

- Test your water for impurities. A distiller might not be the best treatment alternative.
- How much distilled water does your household need? (per day, per year)
- What type of distillers will fit into your needs?
- How easy is the distiller to clean and/or repair?
- What convenience level should a distiller offer (manual or automatic operation)?
- What will you do with the by-products of distillers - waste water, wasteheat, old ACF cartridges?
- Is it 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).
- Investigate equipment before purchasing or renting. Don't rush a purchase.
- Purchase price does not directly indicate a distiller's performance. A moderately priced unit might work as well as expensive units. Consider convenience along with 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.

For Further Information

Contact your county Extension office or the state health department. Additional information can be found in other fact sheets in the *Treatment Systems for Household Water Supplies* series:

- FS 877A Activated Carbon Filtration
- FS 877C Chlorination
- FS 887IM Iron and Manganese Removal
- FS 877RO Reverse Osmosis
- FS 877S Softening
- FS 877P Identifying and Correcting Water Problems

References

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- HE-430 *Household Water Treatment*. NDSU Extension Service.
- FS-5 *Drinking Water: Treatment Guidelines*. University of Maryland Extension Service.
- Water Treatment Handbook*. Rodale Testing, Emmaus, Pa.
- 9.729 *Drinking Water Treatment Devices: Distillers*. Colorado State University Extension Service.



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