

## Package Plants

### Summary

Small water treatment systems often find it difficult to comply with the U.S. Environmental Protection Agency (EPA) regulations. Small communities often face financial problems in purchasing and maintaining conventional treatment systems. Their problem is further complicated if they do not have the services of a full-time, trained operator. The Surface Water Treatment Rule (SWTR) requirements have greatly increased interest in the possible use of package plants in many areas of the country. Package plants can also be applied to treat contaminants such as iron and manganese in groundwater via oxidation and filtration.

### Package Plants: Alternative to Conventional Treatment

#### What is a package plant?

Package technology offers an alternative to in-ground conventional treatment technology. They are not altogether different from other treatment processes although several package plant models contain innovative treatment elements, such as adsorptive clarifiers. The primary distinction, however, between package plants and custom-designed plants is that package plants are treatment units assembled in a factory, skid mounted, and transported to the site.

These units are most widely used to treat surface water supplies for removal of turbidity, color, and coliform organisms with filtration processes. However, many other treatment technologies are available to small systems as package plants. These technologies or a combination of them can be incorporated into a package plant to provide comprehensive water treatment, including:

- . disinfection (chlorination, ozonation, ultra-violet radiation),
- . filtration (bag and cartridge filters, membrane filtration including reverse osmosis or ultra filtration, slow sand filtration, pressure filtration, diatomaceous earth filtration),
- . aeration,
- . ion exchange,
- . adsorption (using powdered activated carbon or granular activated carbon), and
- . softening.

#### How To Select a Package Plant

Package plant systems are most appropriate for plant sizes that treat from 25,000 to 6,000,000 gallons per day (GPD) (94.6 to 22,710 cubic meters per day). Influent water quality is the most important consideration in determining the suitability of a package plant application. Complete influent water quality records need to be examined to establish turbidity levels, seasonal temperature fluctuations, and color level expectations. Both high turbidity and color may require coagulant dosages beyond many package plants design specifications. Pilot tests (tests that evaluate treatment processes and operations on a small scale to obtain performance criteria) may be necessary to select a package plant for more innovative designs using high flow rates and shorter detention time unit processes. Package treatment equipment manufacturers often perform these tests.

#### System Description and Design Considerations

Package plants can differ widely with regard to design criteria, and operating and maintenance considerations.

#### Package Plant Advantages

Package plants arrive on site virtually ready to operate and built to minimize the day-to-day attention required to operate the equipment.

## Package Plants

Other major advantages of package plants are compact size, cost effectiveness, relative ease of operation, and design for unattended operation.

The main advantages of a packaged factory-finished system are savings in engineering, design and installation costs, and operation and maintenance. These features make package plants attractive to communities that must operate on a tight budget.

Package plants can effectively remove turbidity and bacteria from surface water of fairly consistent quality, provided that they are run by competent operators and are properly maintained. Package plants also can be designed to remove dissolved substances from the raw water, including color-causing substances and trihalomethane precursors (which are organic materials in source water that can react with chlorine to form disinfection by-products).

### Package Plant Limitations

Highly variable influent water quality requires a high level of operational skill and attention, and that tends to negate the package plant advantages of low cost and automation.

Despite the relatively large number of package plants in use, many states are reluctant to endorse them completely.

The requirements of the Safe Drinking Water Act and its amendments might challenge package capability. Challenges include the possible inability of package plants to treat multiple types of contaminants.

Many communities are currently using package plants to treat water supplies, but little data has been collected to demonstrate long-term performance and operations of these systems. State agencies responsible for reviewing plans for the installation of package systems must review each potential plan on a case-by-case basis, with only their own experience to judge the potential for success or failure. Presently, there is no national verification process for package plants.

### Types of Package Plant Filtration Systems

#### Conventional Package Plant

Conventional package plants are manufactured by several firms to a variety of specifications. As their name indicates, they contain the conventional processes of coagulation, flocculation, sedimentation, and filtration. Typical design standards for these units are:

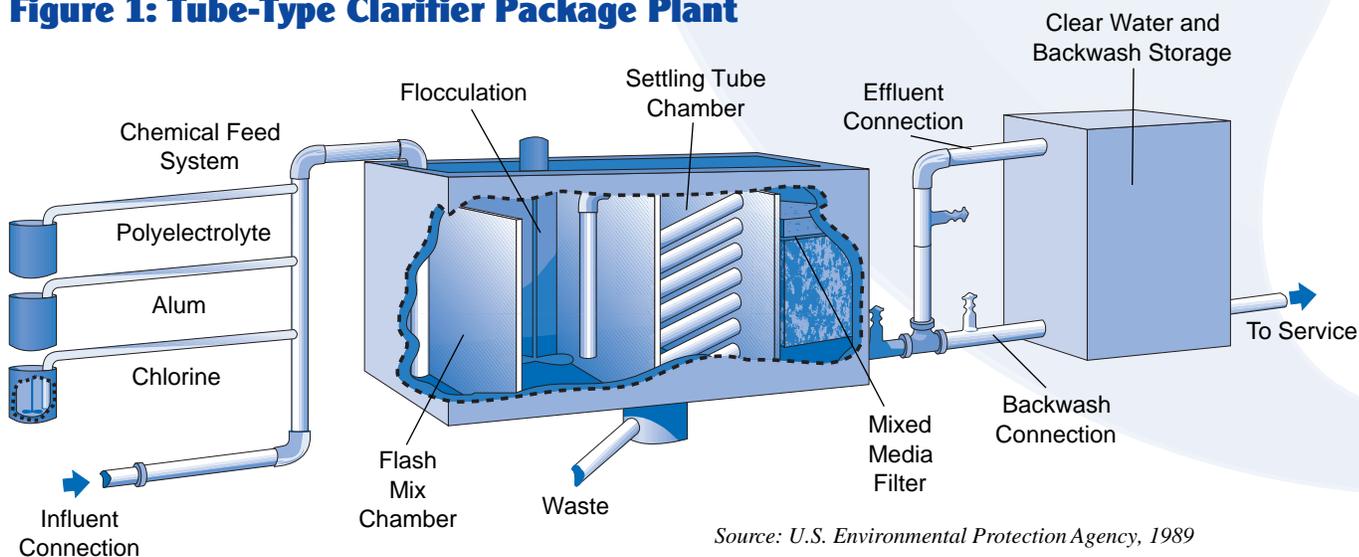
- 20 to 30 minute flocculation detention time,
- 2 hour sedimentation detention time, and
- rapid sand filters rated at 2 gallons per minute (gpm) per square foot (1.34 liter/second/square meter).

#### Tube-Type Clarifier Package Plant

Tube-type clarifier package plants use tube settlers to reduce settling detention time (the average length of time water remains in the tank or chamber).

A flow diagram of a tube-type clarifier package plant is illustrated in Figure 1. This type of

**Figure 1: Tube-Type Clarifier Package Plant**



Source: U.S. Environmental Protection Agency, 1989

plant has two versions with different capacity ranges; one version can treat from 10 to 100 gpm ( 0.63 to 6.3 liters/second), and the other, equipped with dual units, can treat from 200 to 1,400 gpm (12.6 to 88.3 liters/second).

In these package systems, the disinfectant, primary coagulant, and polymer coagulant aid are added before the influent enters the flash mixer; then the water enters the flocculation chamber where mechanical mixers gently agitate the water for 10 to 20 minutes depending on the flow.

The flocculated water then enters the tube settlers, which consist of many 1 inch (2.5 centimeters [cm]) deep, 39 inches (99 cm) long split hexagonal shaped passage-ways. The large surface area of the many 1 inch (2.5 cm) deep tube settlers

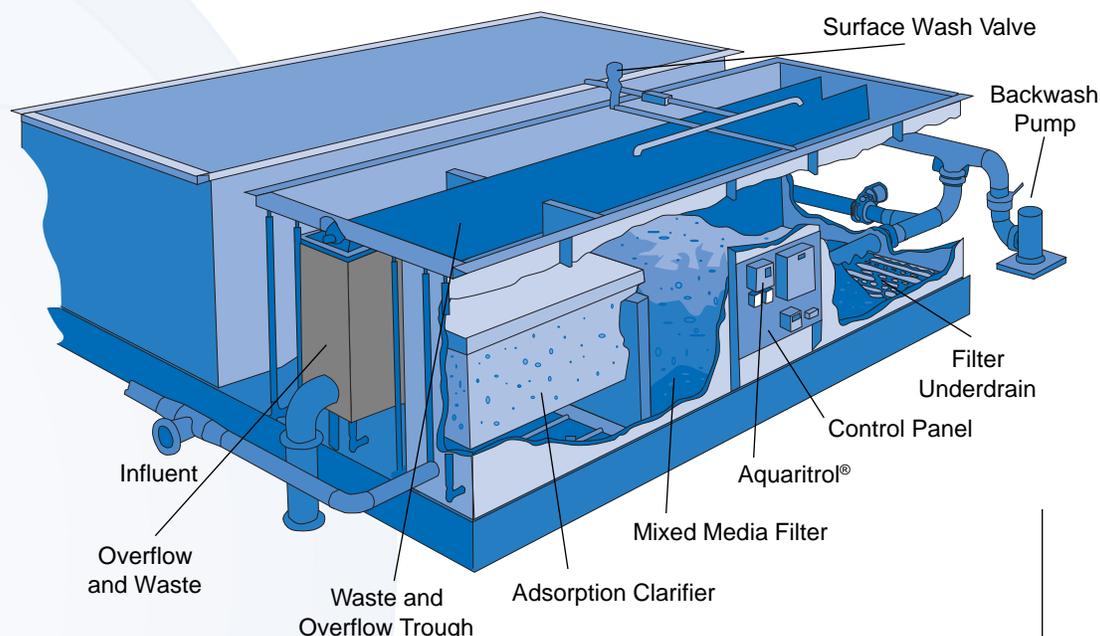
achieves an effective clarification overflow rate of less than 150 GPD/square foot (6.1 cubic meters/day/square meters). Adequate clarification is attained with less than 15 minute detention times.

The clarifier water then enters a gravity flow mixed-media filter (a filter with a coarse-to-fine gradation of filter media or several types of filter media). A constant filtration rate is maintained by a low-head filter effluent pump discharging through a float-operated, level control valve. After a preset headloss is reached, backwashing of the filter is initiated automatically. (Headloss is pressure or energy loss as a result of turbulence caused by the velocity of water flowing and the roughness of the channel walls.) A manual backwash cycle can be initiated any time (if desired). Settled sludge from the tube settlers is flushed during the backwashing cycle. Combining backwashing and tube settler flushing simplifies operations and reduces operator skill requirements.

### Adsorption Clarifier Package Plant

Adsorption clarifier package plants use an upflow filter with low density plastic bead media (called the adsorption clarifier) to replace the flocculation and sedimentation basin, thereby combining these two steps into one. A mixed media filter completes the treatment. Figure 2 shows a typical example.

**Figure 2: Adsorption Clarifier Package Plant**



Source: U.S. Environmental Protection Agency, 1989

While passing through the adsorption media, the coagulant and water are mixed, contact flocculated, and clarified. The mixing intensity, as measured by the mean velocity or gradient, ranges from 150 to 300 feet per second. Flocculation is accomplished through turbulence as water passes through the adsorption media. In addition, flocculation is enhanced by contact between the flocculated materials and the flocculated media. Turbidity is reduced through adsorption of the coagulated and flocculated solids onto the adsorption media and the previously adsorbed materials. The adsorption clarifier can achieve 95 percent or greater removal at 10 gpm/square foot (6.8 liters/second/square meter). This highly efficient clarification method results in extremely compact designs.

Adsorption clarifiers are cleaned by a combination of air scouring followed by water flushing. The air scouring starts the cleaning process for the plastic media used in the clarifier. Adsorption



clarifier cleaning is initiated more frequently than filter backwashing because more solids are removed by the clarifier. The clarifier cleaning process is automatically initiated either by a timer or a pressure switch that continuously monitors headloss across the adsorption media.

The air introduced under the adsorption media causes a vigorous scrubbing action. The scrubbing action dislodges solids, which are washed away by the flow of the incoming water. Flushing is generally timed to occur between every fourth and eighth hour. Complete cleaning of the adsorption media is not desired because performance is enhanced by some residual solids.

### Operation and Maintenance

Package plant operation is simplified by automated features such as effluent turbidimeters connected to chemical feed controls and other operating parameters, such as backwashing. Chemical feed controls are especially important for plants without full-time operators or with variable influent characteristics. Maintenance requirements are well documented in manuals. However, the operator needs to be well acquainted with water treatment principles and the plant manual, and should have attended a comprehensive training session.

The effluent turbidimeters and fail-safe controls are built into many plants to ensure that the finished water does not exceed set turbidity levels. Automated chemical feed systems are especially appropriate for plants without full-time operators or with highly variable influent characteristics.

Typical plant operator and maintenance manuals contain operating principles, methods of establishing proper chemical dosages, operating instructions, and trouble shooting guides.

Periodic visits by the manufacturer to make adjustments to the plant and inspect the equipment operation and performance are recommended. The first visit should be no more than six months after initial operation; the next should follow in another six months. Subsequently, annual visits should be sufficient.

Operators are the critical factor in overall success of any package plant, particularly in situations where raw water quality varies. When the automation fails, the operator needs to turn

off the automatic controls/instrumentation and operate the plant manually.

### Where can I find more information?

Information in this fact sheet was obtained primarily from two sources:

- (1) *Technologies for Upgrading Existing or Designing New Drinking Water Treatment Facilities*, EPA/625/4-89/023; and
- (2) "Package Plants for Small Systems: A Field Study" by Susan Campbell, Benjamin W. Lykins Jr., James Goodrich, Dallas Post, and Trudie Lay. *AWWA Journal*, Nov. 1995 pages 39-47.

*Technologies for Upgrading Existing or Designing New Drinking Water Treatment Facilities* can be ordered free from the U.S. Environmental Protection Agency Office of Research and Development at (513) 569-7562.

The National Drinking Water Clearinghouse (NDWC) offers this document also, but at a cost to help recover photocopying expenses. *Technologies for Upgrading Existing or Designing New Drinking Water Treatment Facilities*, a 209-page book, costs \$30.05. To order, call the NDWC at (800) 624-8301 or (304) 293-4191 and request item #DWBKDM04. NDWC products also may be ordered via e-mail at [ndwc\\_orders@ndwc.wvu.edu](mailto:ndwc_orders@ndwc.wvu.edu). Postal charges are added to orders.

Also, the NDWC's Registry of Equipment Suppliers of Treatment Technologies for Small Systems (RESULTS) is a public reference database that contains information about technologies in use at small water systems around the country. For further information, call the NDWC at one of the above numbers.

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