REVERSE OSMOSIS PLANT LAYOUT

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Summary

The layout and space requirements of the components in a facility using desalting technology to produce drinking quality water are dependent on the dissolved solids content and suspended solids content of the source water as well as the degree of treatment required to condition the product water for its ultimate use. The various components of a desalting process offer a good deal of flexibility in arranging the overall plant layout and appearance.

1. General Considerations

This section includes seawater desalination, brackish water desalination, and nanofiltration plants under the term of reverse osmosis (RO), as the components of each process are very similar.

The layout of an RO plant is based around the treatment functions: raw water pre-treatment, the RO treatment process, permeate post-treatment, and concentrate treatment. All RO plants will include the RO treatment process; however, the other treatment functions can vary considerably based on site-specific conditions and the raw water quality. For example, clear raw water can lead to elimination of the pre-treatment components.

To develop a successful RO plant layout, the designer must consider all treatment functions and components as an integral unit that will operate in unison. After all of the treatment functions and components needed to support the RO treatment process have been identified, the designer must select the specific equipment needed and develop a plant layout to meet the specific needs or space availability of the site. The system designed must meet the owner's needs as to investment costs, operating costs, and compatibility with the surrounding environment. It is rare that any element of an RO plant is independent of the rest of the system.

The space requirement for the RO process equipment is directly dependent on the

dissolved solids content of the raw water. As the dissolved solids content increases, the required feed pressure increases, which requires larger feed pumps and motors. In addition, as the dissolved solids content of the raw water increases the overall system recovery decreases, which means that more membrane area is needed to produce the same amount of permeate. Generally, seawater RO plants require more space than brackish water plants and brackish water plants require more space than nanofiltration plants.

The cleanliness of the raw water also plays a significant role in the configuration of an RO plant. The RO process has a very low tolerance to suspended solids. If suspended solids are present in the raw water, pre-treatment processes must be included to remove most of these solids effectively. Pre-treatment processes require space and add a degree of complexity to the treatment plant operation.

2. Small RO Plants

Small RO plants vary from the needs of a single household up to 400 000 gal day^{-1} (gpd) (1 818 400 l day^{-1}) and usually consist of a single RO unit. Plants of this size are generally assembled on a frame, referred to as a skid, that houses all the main equipment components as well as the support equipment required to be a fully functioning unit. The common approach is to have a supplier purchase all the necessary equipment and components, assemble the skid, and transport it to the RO plant site. The skid is placed in a protective building where it is connected to the raw water, product (permeate), and concentrate piping and electrical power, depending on the type of driver for the feed pump. These skids can be entirely independent, as is the battlefield skid shown in Figure 1 or the skid can depend entirely on electricity to drive the pumps and controls.

Figure 1. Battlefield RO unit.

The basic component of an RO unit is the RO membrane housing. Most commercial membrane housings are cylindrical in shape, which leads to a fairly common configuration for small RO plant skids. The membrane housings have two basic configurations depending on the type of membrane. Hollow fiber membrane housings are usually 12 in. (30 cm) in diameter and 30-48 in. (76-120 cm) long. Thin film membranes are generally 4, 8, or 8.5 in. (10, 20 or 21.5 cm) in diameter and are placed in tubes varying from 120 in. (305 cm) to 280 in. (711 cm) long. Figure 2 shows an 80 000 gal day^{-1} (363 680 l day^{-1}) skid using hollow fiber membranes while Figure 3 shows a 25 000 gal day^{-1} (113 650 l day^{-1}) unit using 4 in. (10 cm) thin film membranes.

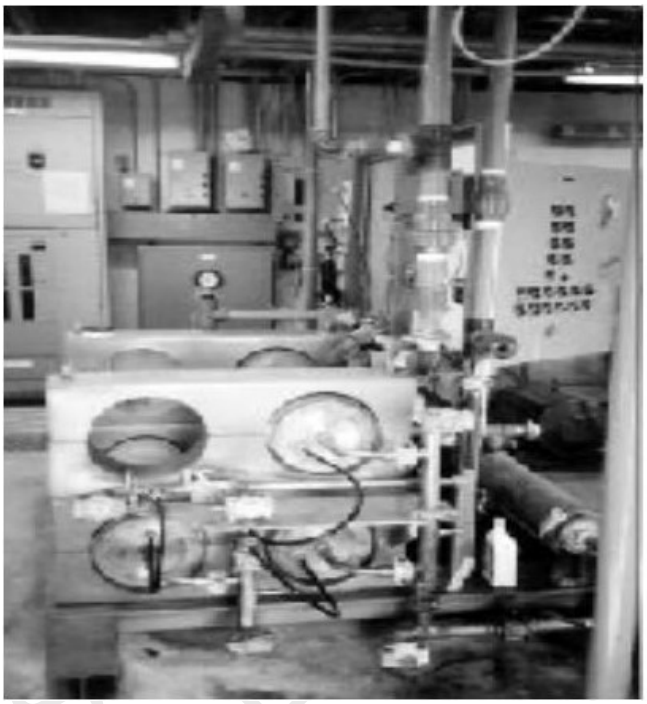

Figure 2. Small hollow fiber RO unit.

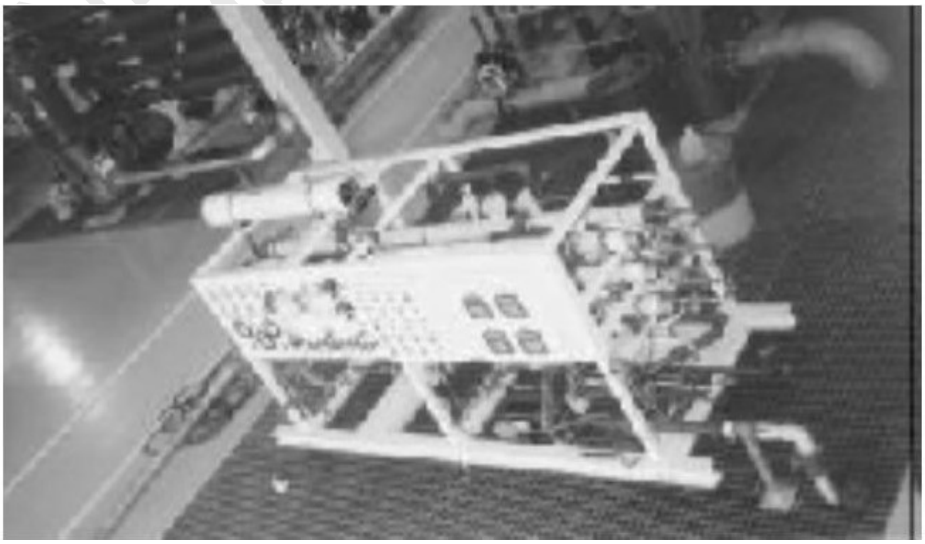

Figure 3. Small thin film RO unit.

The membrane housings are usually supported by a structural frame above the RO skid base. The final filter units and feed pumps are located on the RO skid base. The support equipment, generally including acid and scale inhibitor dosing pumps, chemical storage tanks, and controls, are located at various positions on the RO skid depending on the individual manufacturer's style.

Since the membrane housing units are connected to each other or to pipe headers by means of pipes or flexible hoses, a small RO skid can be configured in a variety of shapes, such as low height with wide base or high height with narrow base.

Small RO units are used to supply drinking water, industrial process water, irrigation water, and boiler feedwater. Support facilities for small RO units can include raw water pre-treatment, permeate treatment, permeate storage, and product delivery pumps. Depending on the size and configuration of these support facilities, they may be supplied by the RO unit fabricator. The support facilities may be located within the same building as the RO unit or located elsewhere. A detailed description of the support facilities is provided in Section 3.

Because small RO units can be assembled in almost any capacity and remove dissolved solids from raw water ranging from seawater to drinking water, they have become quite common. It is economical to assemble an RO unit small enough to produce drinking water for a single home.

Small RO units are commonly used in manufacturing and food processing applications. Since these units can treat feedwater with widely varying concentrations of dissolved solids, many of these units are custom designed for each application. The support facilities must also be custom engineered for each application. During layout and design of an industrial processing facility, space must be provided for the RO unit, ancillary equipment, and support facilities. To determine the required space, the design must characterize the feedwater and determine specific quality requirements for the permeate. From these, the pre- and post-RO unit treatment requirements can be established, the support facilities designed, and space requirements identified. Equipment placement will generally be a function of the overall manufacturing process layout.

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