Wastewater Reuse

Most metal finishing industries have in-house wastewater treatment to economically dispose of the acids, alkali, oils, and dissolved metals in the rinse water and occasional tank solution disposal. However, after treatment this water is typically sent to the sewer since there are still chemicals in the water which makes it unsuitable for reuse. The main post-treatment chemicals in the water are salts such as sodium chloride from the neutralization of hydrochloric acid and sodium hydroxide. Other residual chemicals could include soaps, chelating agents, or surfactants which could be problematic in recycling rinse water.

Typical treated wastewater is:

- Very low in dissolved metals to meet treatment regulations
- High in total dissolved solids (TDS) from neutralization and treatment
- Consistent pH, typically slightly alkaline from metal precipitation process
- At room temperature
- May have some other residuals such as soaps, surfactants, or emulsifiers

The reuse of water will also depend on its intended reuse location. If the water is intended for non-critical rinses, then the final water quality will not be as critical as for use in topping off a plating tank or other use requiring high purity. The water quality criteria needs to be considered early on to determine what treatments are required to obtain the proper water cleanliness for reuse.

Both chemicals and labor were used to treat this wastewater and money was spent to purchase the water and send it to the sewer, so reusing the water in the process is a means of recovering a portion of that cost. A reverse osmosis (RO) system is one means of recovering at least 50% of this treated water and making it very useable as rinse water again.

TDS removal with RO system

The most effective means of removing TDS is reverse osmosis (RO). The process is ideal for removing dissolved materials from water and has become a vast technology for desalinization and potable water purification. System efficiency (water yield) is based on multiple factors including reverse osmosis membrane type, and equipment design such as pressure limits, membrane area, number of cycles, etc.

Reverse osmosis is a technology that filters water with a membrane and allows only water molecules and small amounts of sodium, chloride, or potassium to pass through the membrane (0.5 to 3% leakage of salts is typical). The actual process works by applying pressure to the “dirty” water which forces the clean water through the membrane and leaves the larger molecules and ions behind. Figures 1 and 2 show simple schematics of the RO process and how it works.

Figure 1 Simple explanation of osmosis and reverse osmosis

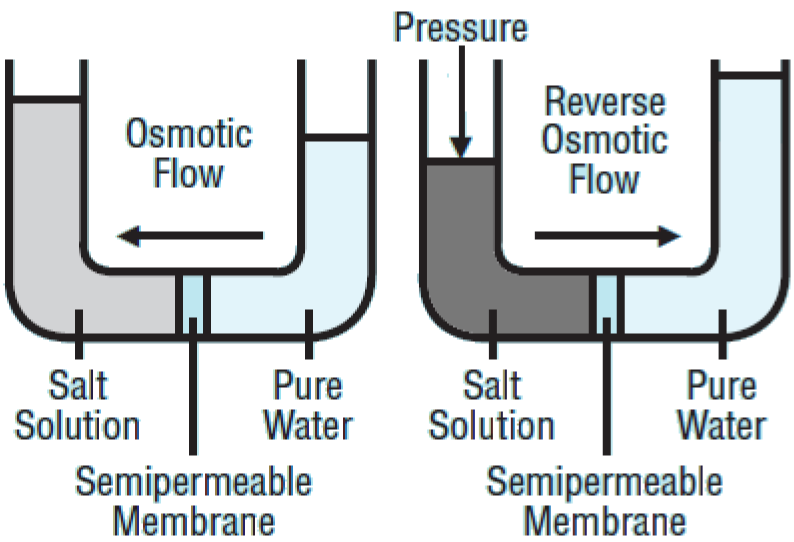
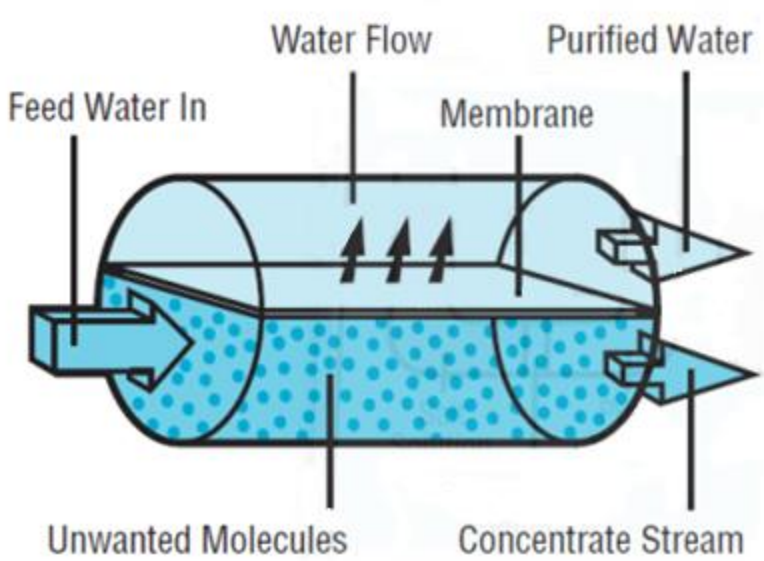
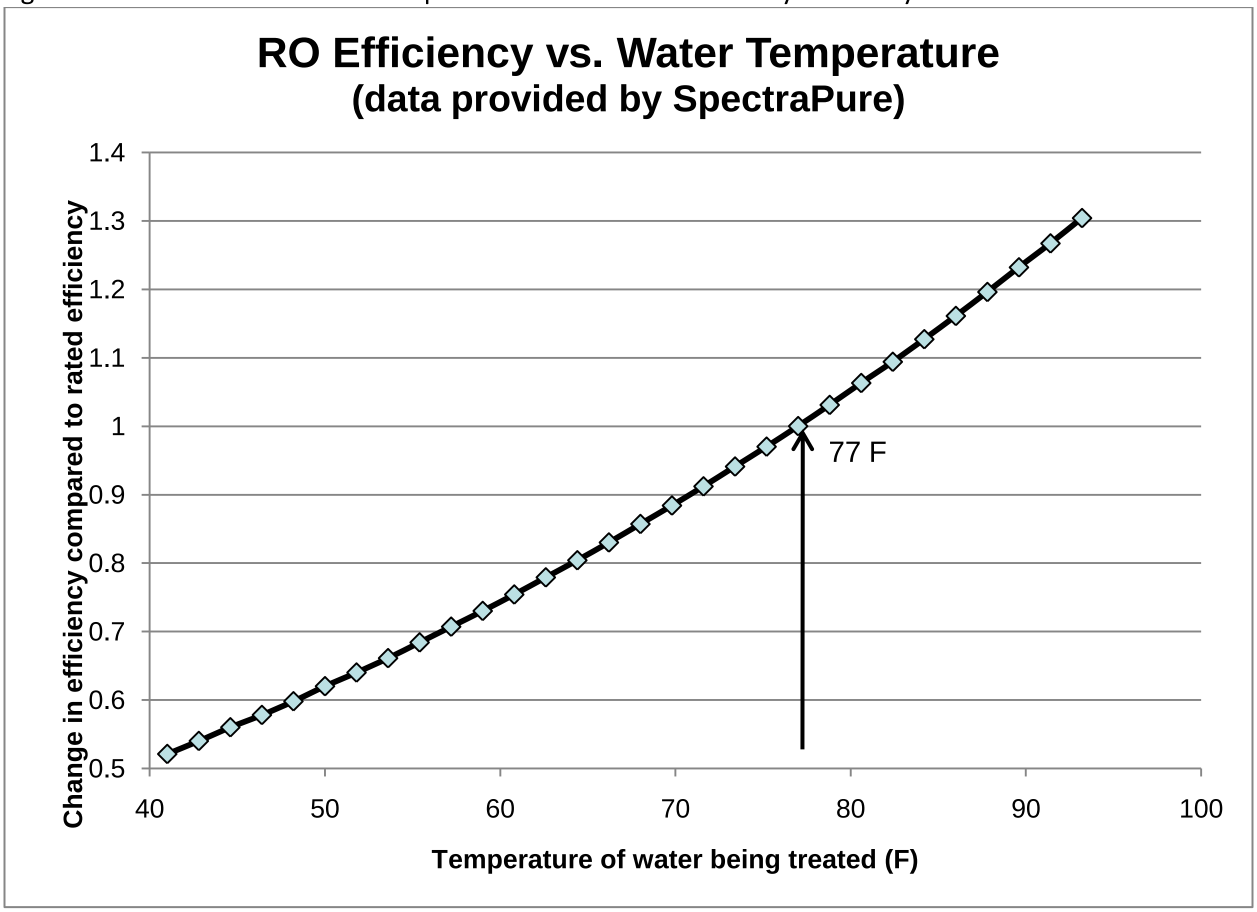


Figure 2 Schematic of how an industrial RO system would work with input water and two output streams



The incoming water properties have an effect on RO recovery efficiency. The incoming TDS levels have a large impact on pure water yields. Higher TDS levels result in lower pure water yields and vice versa. Cold water has much lower yields than warm water. Figure 3 is a typical recovery curve for an RO system at various incoming water temperatures.

Figure 3 Effect of water temperature on RO water recovery efficiency



The RO membrane type will determine the pH limits, temperature limits, membrane life, and potential water pretreatment requirements such as chlorine removal. Table 1 shows the three most common RO membrane categories and their characteristics.

Table 1 Typical RO membrane types and characteristics

Cellulose Acetate	**Low cost**	**Medium water flow**	**pH range 4-8**	**Max. temp. 95 F**	**Oxidation resistant**
Composite (thin film composite, TFC)	**High cost**	**High water flow**	**pH range 2-11,**	**Max. temp. 113 F**	**Vulnerable to oxidizers (chlorine)**
Aromatic Polyamide	**Medium cost**	**Low water flow**	**pH range 4-11**	**Max. temp, 95 F**	**Oxidation resistant**

Advantages of RO filtration:

- Removes everything: ions*, bacteria, viruses, solids, dissolved solids
- Relatively simple, low maintenance system

Disadvantages of RO Filtration:

- Low temperature water produces lower pure water yields
- Higher TDS water produces lower pure water yields
- Tends to leak small amounts of single charge ions (Na^+, K^+, Cl^-)
- Membrane can foul rapidly if suspended solids are high (may require pre-filtration with an ultrafilter)
- The RO process is relatively slow such that the most economical RO unit will be running during both production and non-production hours (filtering stored treated wastewater and storing filtered water during off hours)
- May require pre-treatment to remove chlorination chemicals

Current technologies allow up to about 80% fresh water yields. More typical yields are 50% at optimum conditions of temperature and minimal TDS levels. Even with recovery rates of 50% typical RO systems have a payback of one to two years with water cost. As an example from a case study, an RO unit rated for 15,000 gallons per day water recovery would cost approximately $20,000 and save approximately 3.2 million gallons per year ($17,000 savings/year).

Before purchasing an RO system it is important to implement other water savings measures first so that the RO system is properly sized for the reduced water volumes. Otherwise, the RO system will be underutilized as other water savings measures are implemented.

Example of a small industrial RO system

RO Ultratec 20,000 GPD System

Water Deionization
For critical water purity, treated wastewater can go through both an RO system followed by a water deionization system (ion exchange resin column system). The RO system will remove the majority of the ions, suspended solids, bacteria, dissolved organics, etc. but will leave small residuals of sodium, chlorides, and potassium ions. If these ions need to be removed for critical rinsing or chemical tank makeup water then the next step would be deionization (DI).

Figure 4 shows the mechanism of deionization for both positive and negative ion removal. Following deionization the water will be of high enough purity to allow both critical rinsing and chemical tank makeup water. Only in the most extreme conditions would additional treatment be required, such as carbon dioxide removal, to obtain ultra-pure water.

The DI system should be sized for water demand and expected ion loading rates. An ion exchange resin can take only a certain amount of ions per cubic foot before the resin must be regenerated to flush out the adsorbed ions. After regeneration the resin is able to be reused. The waste chemical used in flushing out the resin will need to go to waste treatment due to either high acidity or high alkalinity. If resin columns are too small for the water volume and ion loads, the regenerations will have to be done too frequently. An oversized system will be regenerated much less frequently but runs the risk of developing biological growth inside the column. Hence the importance of properly sized systems.

Figure 4 Explanation of how deionization resin beads work