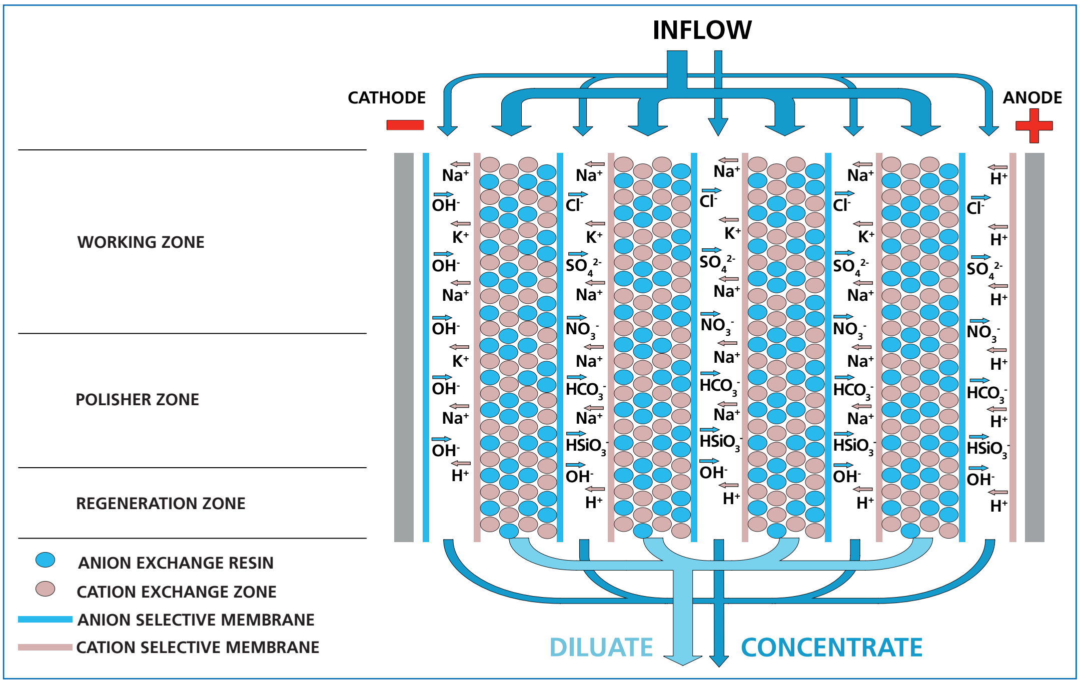
Fundamentals and processes

Electrodeionization (EDI) is a continuous process that removes dissolved salts and other ionised and ionisable substances from water. In process water treatment, EDI is used after reverse osmosis as a final polisher to achieve the highest water qualities.

Functional principle

An EDI module is made up of several chambers separated by anion- and cation-selective membranes and arranged between a cathode and an anode. In order to improve ion transport, the chambers are filled with mixed-bed resin. The **driving force** for ion transport is a **DC voltage** applied across the cathode and anode. Depending on their charge, the cations are transported in the direction of the cathode and the anions in the direction of the anode. Through the arrangement of the **ion-selective membranes**, product channels are created, from which the cleaned water is brought together as a **diluate**. The concentrated ions are discharged via the wastewater channels of the EDI module (**concentrate**).



EDI module functional principle

In continuous operation, three zones are formed in an EDI. In the **working zone**, highly ionised substances like Na^+ are removed. In the **polisher zone**, water is split into hydrogen and hydroxide ions (H^+ and OH^-) due to the greatly reduced conductivity and the electrical potential of the DC voltage.
These continuously regenerate the mixed-bed resin, enabling it to absorb and ionise even weakly dissociated ingredients such as SiO_2 and CO_2. Through the DC voltage, these substances are transported into the concentrate channels and discharged.
Ideally, the **regeneration zone** is only used for water splitting and regeneration of the mixed-bed resins in order to provide a buffer zone for optimal product quality.

Usage possibilities

Like the mixed-bed filter, the EDI process is used for the fine cleaning of demineralised water. Conductivity of ≤ 0.056 µS/cm (at 25°C) can be achieved (alternatively, electrical resistance ≥ 18 MOhm cm is often specified for ultra-pure water). As a continuous process without the need for regeneration chemicals, EDI is ideal for the post-treatment of permeate from reverse osmosis systems.
The modular design enables space-saving mounting on plant framework.

EDI is significant wherever there are high requirements for ultra-pure water, such as in the power plant sector or the semiconductor or pharmaceutical industries.

Inflow conditions

EDI requires high inflow water quality, which can be achieved through upstream single- or two-stage reverse osmosis. Depending on the usage area and EDI type, the inflow parameters are approximately in the following range:

Inflow temperature:	5-45	°C
Total hardness:	< 0.03-0.06	°dH
Conductivity:	< 10-40	µS/cm
pH value (in operation)	5-9	
Silicate (SiO_2):	< 0.5-1	mg/l
Carbonic acid (CO_2):	< 5-10	mg/l
TOC:	< 0.5	mg/l

The feedwater must also be free of undissolved substances, oxidants, iron and manganese.

Free carbonic acid has a significant influence on the achievable ultra-pure water quality after EDI. Since CO_2 as a gas is not removed from water with a reverse osmosis membrane, additional measures must be taken depending on the raw water quality and pre-treatment. As a chemical-free and tried-and-tested process, membrane degassing in the reverse osmosis permeate can effectively reduce the CO_2 content. Alternatively, a pH value increase (e.g. through sodium hydroxide dosing) can be used to convert CO_2 to HCO_3^- before reverse osmosis. Depending on the lime-carbonic acid equilibrium, HCO_3^- is retained as an ion on the reverse osmosis membrane.

Operating equipment and service life

EDI is basically a chemical-free process and only requires an electrical current for the application of a DC voltage. Through the discharge of dissolved salts via the concentrate, wastewater amounting to approximately 5-10% of the inflow stream is produced. This wastewater can be returned to the reverse osmosis inflow if discharge is not desired and water requirements are to be minimised.

Since crystallisation (scaling) and, in some cases, biofilm (fouling) can also form in EDI modules over time, the performance (product volume flow and ultra-pure water quality) may deteriorate over time. With good inflow conditions, the service life of EDI modules is generally 5-7 years or longer.
In addition to replacing the EDI module, chemical cleaning can also help to restore the original performance to a large extent.

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