QUA®

FEDI®

Fractional Electrodeionization

from EDI to FEDI®

The evolution of high purity water production

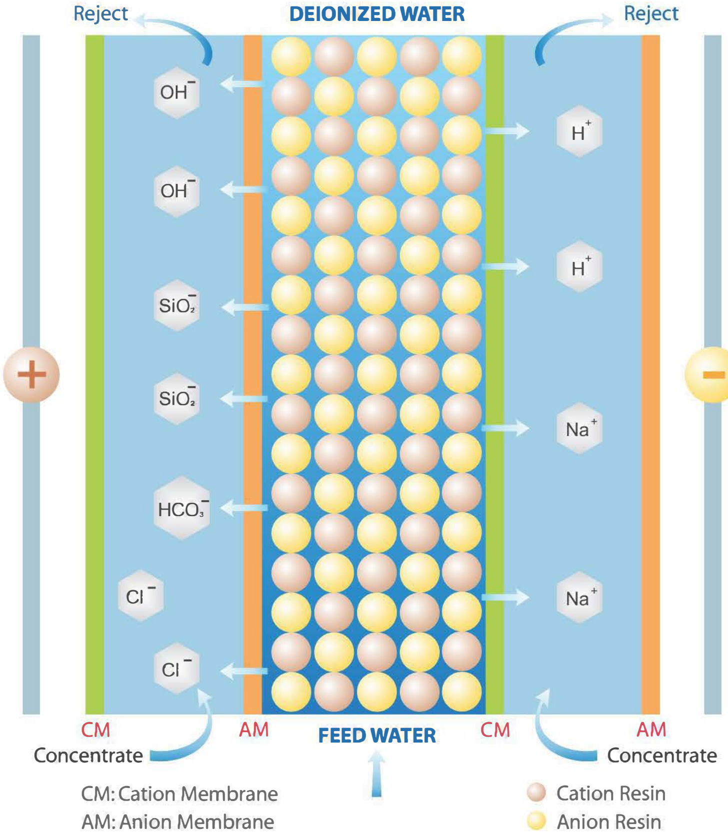
EDI

THE CONVENTIONAL PROCESS

Electrodeionization (EDI) invented over 20 years ago, is a continuous and chemical free process that removes ionized and ionizable impurities from the feed water using DC power. EDI is most commonly used to treat reverse osmosis (RO) permeate and replace mixed bed ion exchange (MB) to produce high purity water of up to 18 M Ω.cm. EDI eliminates the need to store and handle hazardous chemicals required for resin regeneration and the associated neutralization steps.

Conventional EDI is limited by feed water hardness, free CO_2 and Silica. Recovery of the EDI process is dependent upon feed water hardness.

Electrodeionization Cell



"FEDI™ - The Next Generation of EDI"

FEDI®

MAKING A GOOD TECHNOLOGY EVEN BETTER

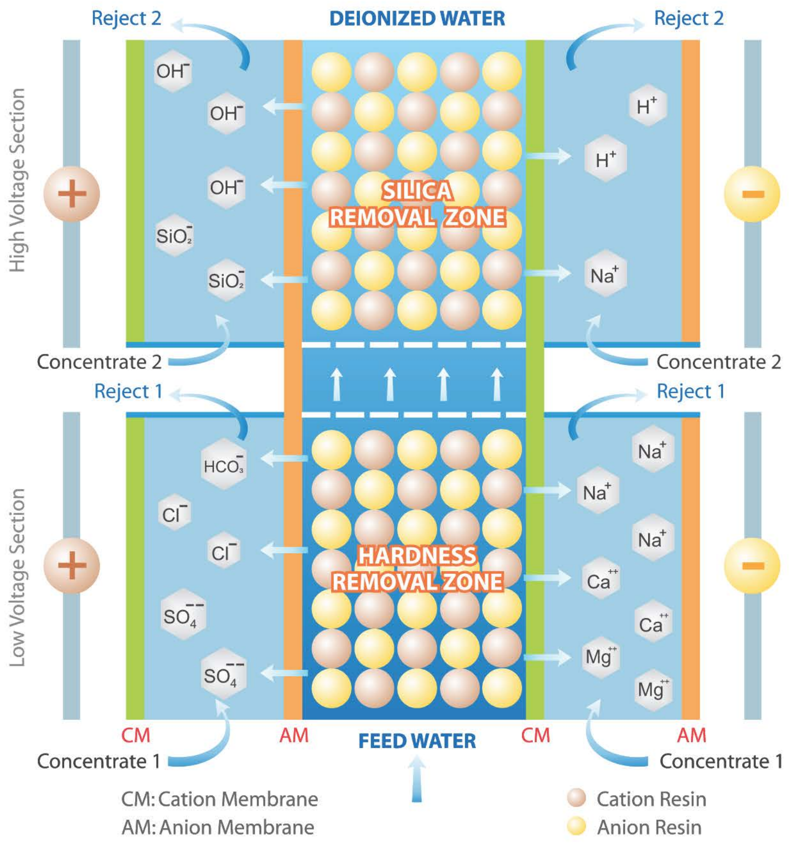
The Fractional electrodeionization (FEDI®) process is an advancement in EDI. It was developed taking into account the above limitations of conventional EDI which, if not addressed properly, lead to scaling and reduced module efficiency and reliability. There are two types of ionic impurities removed in an EDI process; strongly ionized impurities (divalent ions such as Ca, Mg, SO_4 and monovalent ions such as Na, Cl and HCO_3) and weakly ionized impurities (such as CO_2, B and SiO_2).

Conventional EDI addresses both strongly and weakly ionized impurities in the same manner with the application of one current per module. The hardness limitations in conventional EDI essentially exist because of the alkaline conditions in the concentrate compartment of the EDI module which can lead to hardness precipitation, even at very low values in the feed water.

Both types of ionic impurities require a different driving force (current) for movement and separation. Strongly ionized impurities require less current whereas weakly ionized impurities require more. Rather than applying one current to the entire module the FEDI® process differentiates the treatment of weakly ionized and strongly ionized impurities by application of different current and voltage in a two stage process. This allows a significant portion of strongly ionized impurities, mainly the divalent ions which can cause precipitation at a higher voltage, to be removed in stage 1. Subsequently, a higher voltage is applied for removal of weakly ionized impurities in stage 2. The rejected ions from both the stages are removed using separate reject streams, preventing hardness precipitation.

"The FEDI® process was developed taking into account the limitations of conventional EDI. The patented dual voltage process allows for a higher flexibility and tolerance to inlet water conditions thus lowering the risk of scaling, improving plant design economics and reliability."

Fractional Electrodeionization Cell



STAGE 2: SILICA REMOVAL ZONE

Weakly ionized impurities (such as Silica and Boron) are removed in stage-2. Higher voltage and current in this zone provides efficient removal of residual weakly ionized impurities as significant amount of strongly ionized impurities have already been removed in the stage-1. The higher voltage also ensures stage-2 to remain in highly regenerated state resulting in superior quality of final product water. The high pH feed condition in stage-2 helps with efficient removal of Silica and Boron.

STAGE 1: HARDNESS REMOVAL ZONE

This section, where a significant amount of strongly ionized impurities such as hardness are removed, operates at a lower voltage and current and requires about one third of the total power consumed. The acidic condition in the concentrate chamber of stage - 1 prevents scale formation, thus giving a higher hardness tolerance to the FEDI™ process. The patented ion exchange media construction used in the module further reduces hardness scaling potential.

FEDI® TWO STAGE SEPARATION

Hardness is the scaling component and the main limiting factor for feed conditions in a conventional EDI. By incorporating a two stage separation process with different voltages the FEDI® process is able to:

- **Achieve a higher hardness tolerance** by having distinctly different concentrate chambers with separate reject streams and thus reducing the potential of hardness scaling.
- **Optimize power consumption** by using higher electrical current only where required.
- **Ensure best quality water continuously** & **consistently** by removing a major part of deionization load in the 'hardness removal zone' while residual ionic impurities are effectively removed in the 'silica removal zone' which stays in polishing mode.

CLEAN, GREEN, SAFE, HIGH PURITY WATER PRODUCTION

Electrodeionization offers significant advantages over Mixed Bed (MB) ion exchange, particularly the minimization of hazardous chemicals.

BENEFITS	MB	EDI	FEDI®
Non-hazardous Green Technology Generation of ultra-pure water without having to discharge chemical laden regeneration waste streams	✗	✓	✓
Safety Considerations Elimination of hazardous chemicals such as acid and caustic required for regeneration of ion exchange resin in a conventional demineralization process • No need for chemical storage • No chance of chemical spillage • No need to transport chemicals to and from project site	✗	✓	✓
Treated Water Quality Improvements Produces from 1 M Ω.cm high purity water to 18 M Ω.cm ultra pure water with very low levels of silica & boron.	✓	✓	✓
Produces ***consistent and continuous*** good quality water	✗	✓	✓
No down time as no regeneration is required	✗	✓	✓
Standby units not required	✗	✓	✓
Multiple stacks are used for higher flows, which offers flexibility for replacement/repair for long term	✗	✓	✓
Ease of operation	✗	✓	✓
Total installed cost and total lifecycle cost savings	✗	✓	✓
Value Addition in FEDI® Process Flexibility to handle feed condition variations due to dual voltage operation	NA	✗	✓
Higher feed hardness tolerance thus avoiding or eliminating module scaling	NA	✗	✓
Effective and efficient removal of weakly and strongly ionized impurities	NA	✗	✓
Optimum power consumption	NA	✗	✓

FEDI® process has received two U.S. Patents.

PATENT-1
US Patent No – 6,896,814 B2 for Fractional Deionization Process

PATENT-2
US Patent No – 7,163,964 B2 for Method for preparing an Ion exchange media

SPECIFICATIONS : QUA® FEDI® STACK

TYPICAL FEED & PRODUCT WATER SPECIFICATIONS

PARAMETERS	UNIT	SPECIFICATION
FEED		
Feed Conductivity Equivalent (FCE) (Including CO_2)	µS/cm	< 40
pH		5 – 10
Silica (Reactive)	ppm	< 1.0
Total Hardness as $CaCO_3$	ppm	<3.0
TOC	ppm	< 0.5
Heavy Metals (Fe, Mn etc.)	ppm	< 0.01
Free Chlorine as Cl_2	ppm	< 0.05
Feed Water SDI		< 1.0
PRODUCT		
Product Resistivity	M Ω.cm	>5 to 18
Silica	ppb	<5 to 50

OPERATING CONDITIONS

Table 1

PARAMETERS	UNIT	SPECIFICATION
Typical Product Flow	m^3/hr	3.5
	gpm	15.4
Maximum Product Flow	m^3/hr	5.0
	gpm	22
Minimum Product Flow	m^3/hr	1.5
	gpm	6.6
Concentrate Flow (Conc.-1+ Conc.- 2)	m^3/hr	$\leq$ 0.5
	gpm	2.2
Electrode Rinse Flow	m^3/hr	0.1
	gpm	0.44

Table 2

PARAMETERS	UNIT	SPECIFICATION
Recovery	%	Up to 95
Feed Water Temperature	°C	10 – 40
	°F	50 – 100
Pressure Drop (Feed to Product)	bar	1.0 – 4.2
	psi	15 to 60
Maximum Operating Pressure	bar	7.0
	psi	100

Table 3

PARAMETERS	UNIT	SPECIFICATION
Voltage-1/ voltage-2 – Typical	VDC	300 / 450
Voltage-1/voltage-2 - Maximum	VDC	500 / 500
Current-1/current-2- Typical	Amp.	1.5 / 2.5
Current-1/current-2 - Maximum	Amp.	2.5 / 3.5

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