QUA®

FEDI®

Fractional
Electrodeionization

from EDI to FEDI®

The evolution of high purity water production

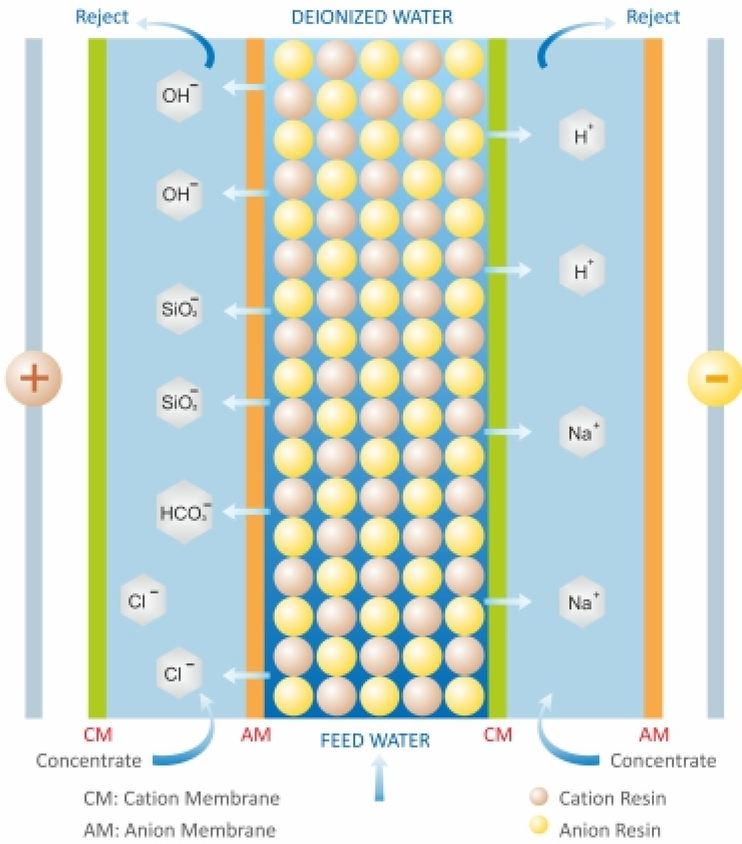
EDI

THE CONVENTIONAL PROCESS

The Electrodeionization (EDI) process, invented over 20 years ago, is a continuous, 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 (MB) ion exchange; producing high purity water of up to 18 MΩ.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. The EDI recovery process is dependent upon the feed water hardness.

Electrodeionization Cell



"FEDI® - The Next Generation of EDI"

"The FEDI® process was developed by 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, and improving the plant's design economics and reliability."

FEDI®

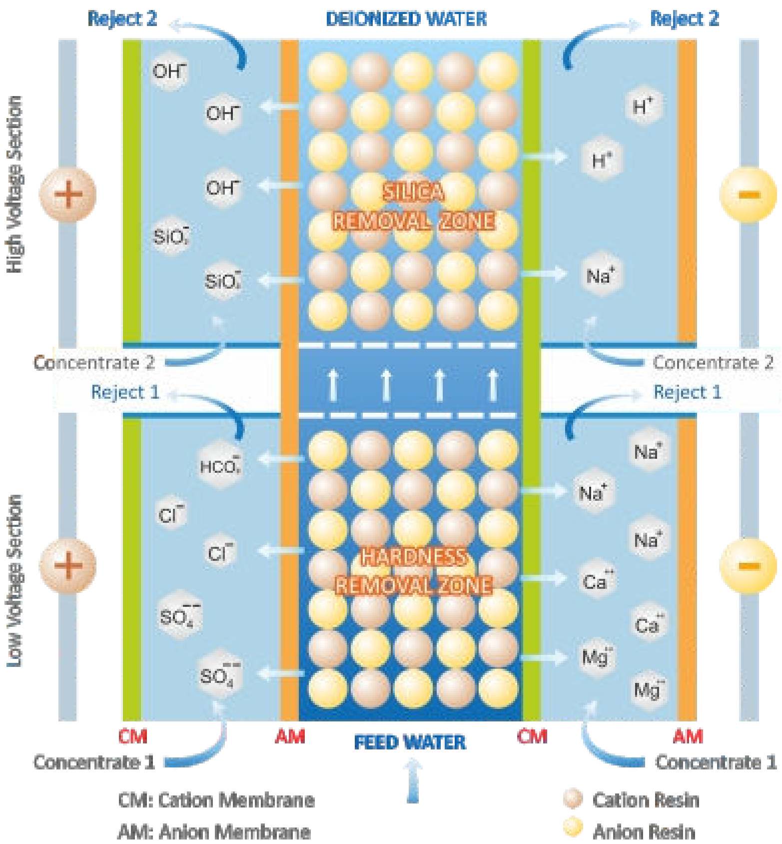
MAKING A GOOD TECHNOLOGY EVEN BETTER

The Fractional Electrodeionization (FEDI®) process is an advancement of EDI. It was developed by taking into account the limitations of conventional EDI described above 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 the 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 applying different currents and voltages 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 removing weakly ionized impurities in Stage-2. The rejected ions from both stages are removed, using separate reject streams, thus preventing hardness precipitation.

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 Stage-2 provide efficient removal of the residual weakly ionized impurities, while a significant amount of strongly ionized impurities have already been removed in Stage-1. The higher voltage also ensures that Stage-2 will remain in a highly regenerated state resulting in superior final product water quality. 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, requiring about one third of the total power. 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 the hardness scaling potential.

CE Certified
UL Listed
FDA compliant for Pharma Rx stacks

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 the best water quality, continuously & consistently** by removing a major part of the deionization load in the 'hardness removal zone', while residual ionic impurities are effectively removed in the 'silica removal zone', which stays in a 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			
Capable of generating 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 MΩ. cm high purity water to 18 MΩ. cm ultra pure water with very low levels of silica & boron.	✓	✓	✓
Produces **consistent and continuous** desired water quality	✗	✓	✓
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, and potential plant expansion needs	✗	✓	✓
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 :

TYPICAL FEED & PRODUCT WATER SPECIFICATIONS

PARAMETERS	UNIT	SPECIFICATION
FEED WATER		
Feed Conductivity Equivalent (FCE) (Including CO_2)	µS/cm	< 40
pH		5-10
Silica (Reactive)	ppm	< 1
Total Hardness as $CaCO_3$	ppm	<3
TOC	ppm	< 0.5
Heavy Metals (Fe, Mn etc.)	ppm	< 0.01
Free Chlorine as Cl_2	ppm	< 0.05
Feed Water SDI		< 1
PRODUCT WATER		
Product Resistivity	MΩ.cm	5-18
Silica	ppb	<5-50

OPERATING CONDITIONS

Table 1

PARAMETERS	UNIT	SPECIFICATION							
Models* →		FEDI-1/FEDI-2			FEDI-2 HF	FEDI-Rx			
		10X	20X	30X	30X	5X	10X	20X	30X
Type →		High Hardness Tolerant			High Flow	Pharmaceutical			
Typical Product Flow	m^3/ hr	1.2	2.3	3.5	5.8	0.6	1.2	2.3	3.5
	gpm	5.5	10	15.4	25.5	2.6	5.5	10	15.4
Maximum Product Flow	m^3/ hr	1.7	3.3	5	7.2	0.85	1.7	3.3	5
	gpm	7.5	14.5	22	31.7	3.7	7.5	14.5	22
Minimum Product Flow	m^3/ hr	0.5	1	1.5	4.5	0.25	0.5	1	1.5
	gpm	2.2	4.4	6.6	20	1.1	2.2	4.4	6.6

*The values noted above are "typical". Refer to the separate datasheet for each of the various models to view their respective values.

Table 2

PARAMETERS	UNIT	SPECIFICATION							
Models* →		FEDI-1/FEDI-2			FEDI-2 HF	FEDI-Rx			
		10X	20X	30X	30X	5X	10X	20X	30X
Type →		High Hardness Tolerant			High Flow	Pharmaceutical			
Recovery	%	Up to 95			Up to 95	Up to 95			
Feed Water Temperature	°C	10-40			10-40	10-50			
	°F	50-100			50-100	50-122			
Pressure Drop (Feed to Product)	bar	1.7-2.4			1.4-2.1	1.4-2.4			
	psi	25-35			20-30	20-35			
Maximum Operating Pressure	bar	6.9			6.9	6.9			
	psi	100			100	100			

*The values noted above are "typical". Refer to the separate datasheet for each of the various models to view their respective values.

Table 3

PARAMETERS	UNIT	SPECIFICATION							
Models* →		FEDI-1/FEDI-2			FEDI-2 HF	FEDI-Rx			
		10X	20X	30X	30X	5X	10X	20X	30X
Type →		High Hardness Tolerant			High Flow	Pharmaceutical			
Voltage-1/Voltage-2 - Typical	VDC	90/140	170/270	250/400	175	60	110	210	300
Voltage-1/Voltage-2 - Maximum	VDC	200	350	500	400	90	200	350	500
Current-1/Current-2 - Typical	AMP	1.5/2.5			4	4			
Current-1/Current-2 - Maximum	AMP	2.5/3.5			6	6			

*The values noted above are "typical". Refer to the separate datasheet for each of the various models to view their respective values.

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