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PMX® PERFORMANCE
A CASE OF SUCCESS

ELECTRODE TECHNOLOGIES & WATER TECHNOLOGIES

Decio Barros \ Sales and Technical Assistance Director

Luiz Gonzaga \ Sales and Technical Assistance Engineer

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DE NORA: A UNIQUE BLEND OF DIFFERENT EXPERTISE

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DE NORA IDENTITY

Our daily activities are driven by our values

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DE NORA AT A GLANCE

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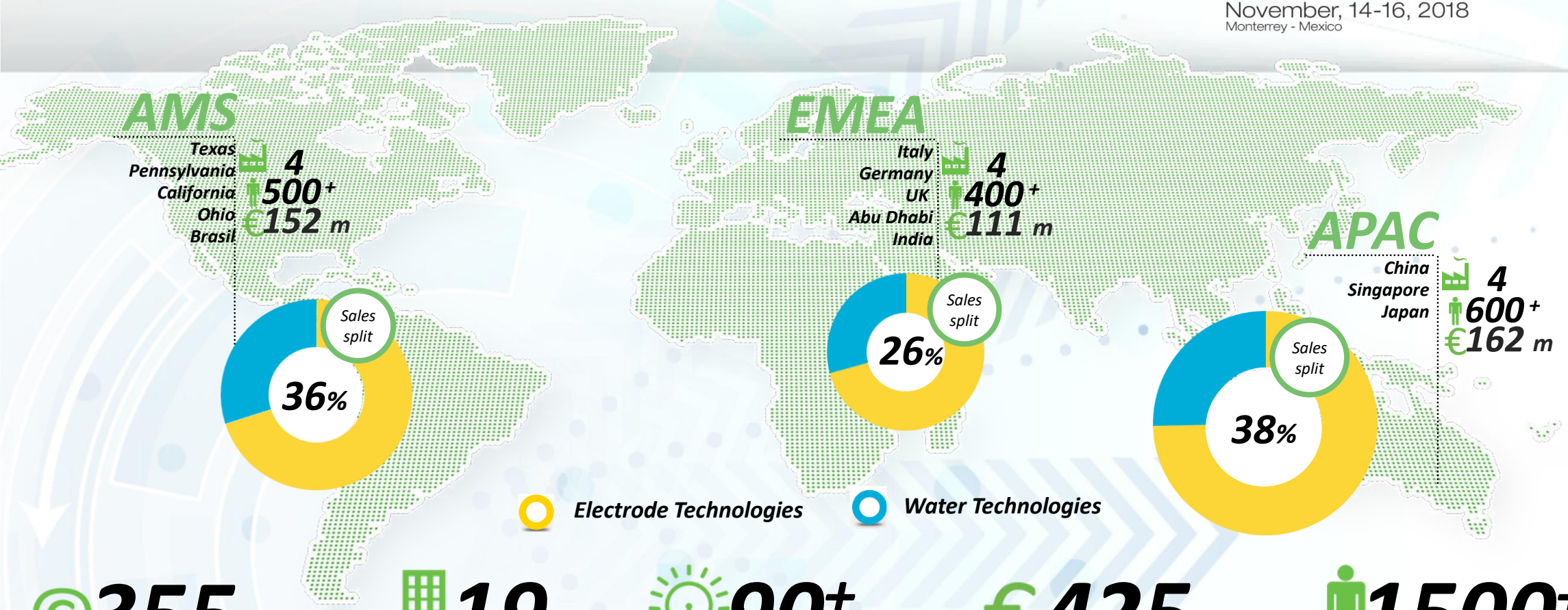

©355 Patent families

19 Locations

90+ Years of Innovation

€425m 2017 Revenues

1500+ People

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OUR COMMITMENT

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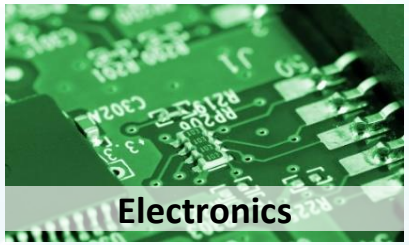
Delivering innovative products and solutions to diversified industries to address customers' needs

ELECTRODE TECHNOLOGIES

electrochemistry at your service


Chlorine & Caustic Soda

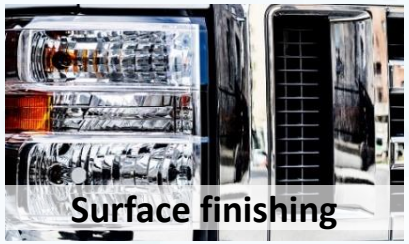

Electronics


Mining


Cathodic protection


Renewable energy storage


Pools


Surface finishing


Pulp & Paper

WATER TECHNOLOGIES

water made easy


Municipal


Energy


Oil & Gas


Marine


Food Processing & Sanitising


Industrial water treatment

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FUTURE CHALLANGES

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- Climate change
- Population growth
- Carbon footprint
- Resource scarcity

Strategic arenas

Energy storage

Mining

Energy savings and resource recovery

Water treatment

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DE NORA UNIQUE EXPERTISE

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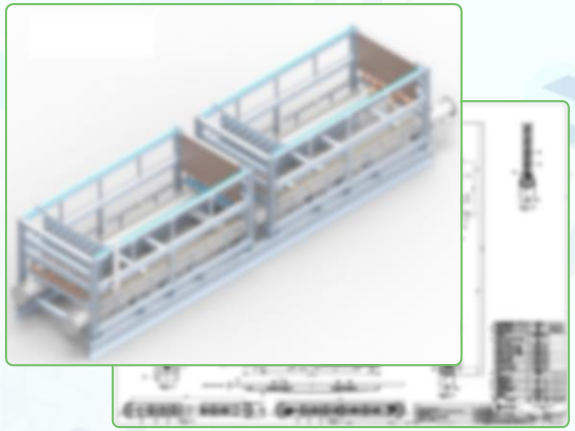
Coating domain, cell design engineering, cell mechanical manufacturing

R&D labs: coating development

- 3 R&D facilities (Italy, US, Japan)
- +100 researcher involved
- 30 lab-scale membrane C/A cells
- several testing protocols

Cell design engineering



- Engineering services for tkUCE
- R&D projects
- Prototyping and field testing

Electrodes & Cell manufacturing

- Production, commercialization, technical assistance and services for dimensional stable electrodes with precious metal coatings
- New assembly, repair and re-activation of Chlor-Alkali Membrane cells
- Laser welding
- Robot TIG welding
- …
- …

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De Nora do Brasil is prepared to apply anodic and cathodic coating up to 35,000 m²/year of activated surface.

Part of the building	Area (m²)
Mechanical Activities	1800
Coating Activities	1700
Administration	900
Warehouse	300
Others	100
Total Area	45000

ACTIVATION TYPES:

- ❑ Anodic
- ❑ Cathodic
- ❑ Platinization

EXPANSION PROJECT:

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Not yet customers
Long term customers
New customers

BRASKEM AL
PRODUQUIMICA
BRASKEM BA
DOW
BAHIA SUL
CENIBRA
JARAGUA
CHEMTRADE
KATRIUM
ARACRUZ
IPAPER
AKZONOBEL
UNIPAR CARBOCLORO
UNIPAR INDUPA

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PMX® TECHNOLOGY

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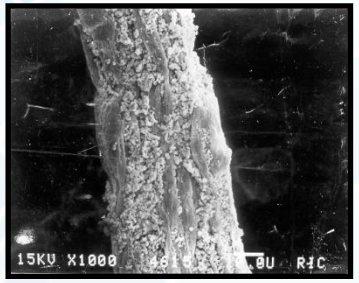
WHAT IS POLYRAMIX® TECHNOLOGY?

MEETS ENVIRONMENTAL REQUIREMENTS – Polyramix is a registered trademark

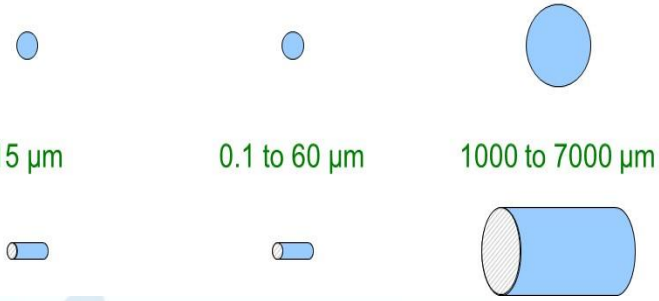


Embedded or Attached Zirconium Oxide Particles

Branch Chain Structure

OCCUPATIONAL HEALTH – Environmentally Safe Technology

	Peak Carcinogenic	Chrysotile Asbestos	Polyramix®
Diameter	0.0625 to 1 µm	0.1 to 3 µm	10 to 100 µm
Length	15 µm	0.1 to 60 µm	1000 to 7000 µm



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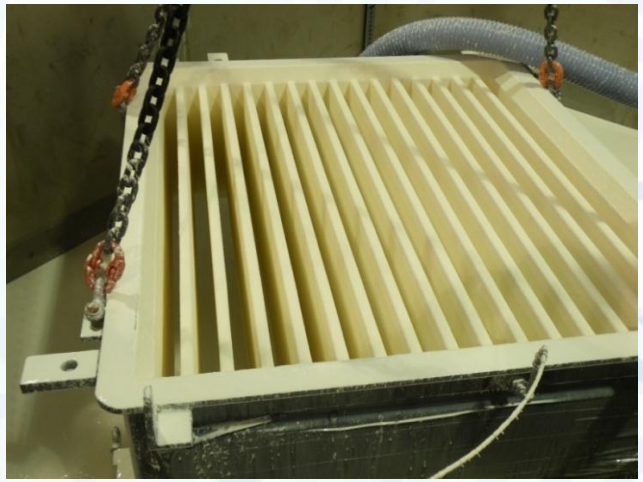
WHAT IS POLYRAMIX® TECHNOLOGY?

Raw materials are non-carcinogenic.

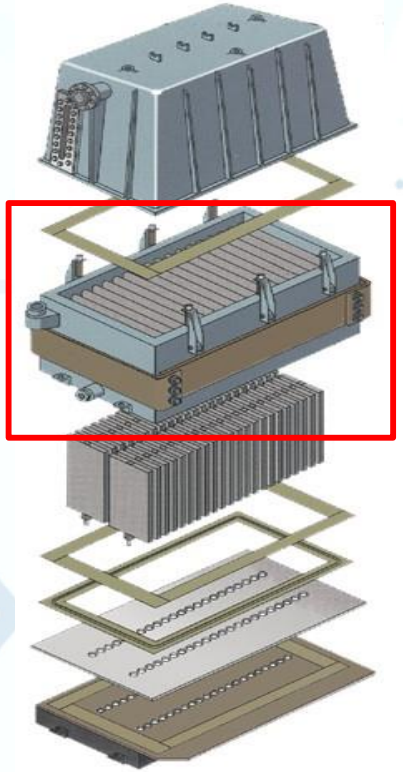
PMX® Fibers cannot be suspended in air.

Less waste diaphragm disposal.

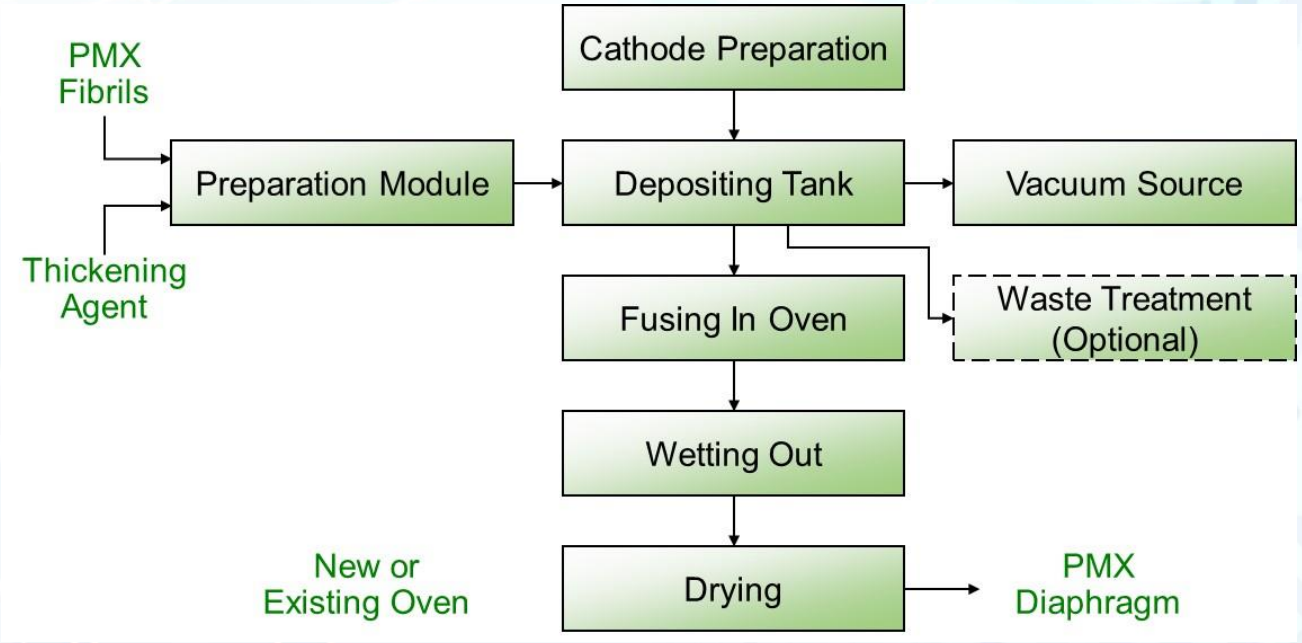
Reduced product liability.

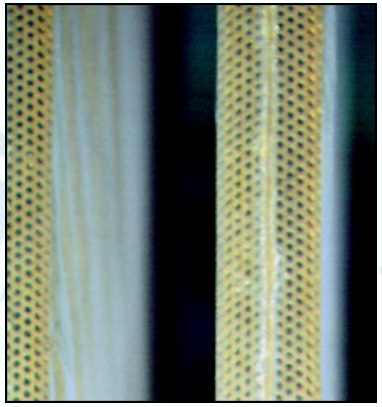


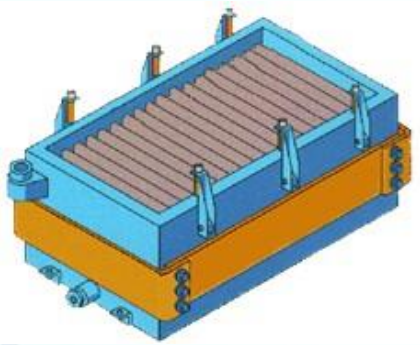
Many similarities exist between polymer modified asbestos diaphragm depositing and Polyramix® diaphragm depositing

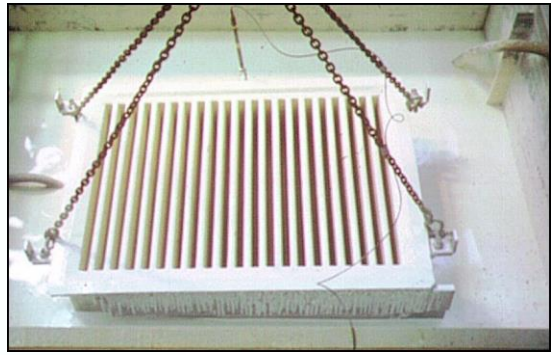


HOW IS POLIRAMIX APPLIED?









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THE IMPORTANCE OF BRINE QUALITY

Brine Specification for PMX Diaphragms

Parameter		Typical		Specification	
Sodium Chloride	NaCl	310 - 320	gpl	320	gpl Minimum
pH	pH	2 - 11		2.5 - 3.5	
Calcium	Ca	0.8 - 1.2	ppm	3.0	ppm Maximum
Magnesium	Mg	< 0.1	ppm	0.3	ppm Maximum
Iron	Fe	< 0.06	ppm	0.1	ppm Maximum
Nickel	Ni	< 0.1	ppm	0.1	ppm Maximum
Manganese	Mn	< 0.01	ppm	0.01	ppm Maximum
Barium	Ba	< 0.01	ppm	0.01	ppm Maximum
Cobalt	Co	< 0.01	ppm	0.01	ppm Maximum
Mercury	Hg	< 0.1	ppm	1	ppm Maximum
Aluminum	Al	< 0.1	ppm	1	ppm Maximum
Phosphate	Na_3PO_4	< 0.5	ppm	1	ppm Maximum
Fluoride	F	< 0.5	ppm	1	ppm Maximum
Silicon	Si	< 5	ppm	15	ppm Maximum
Sulfate	Na_2SO_4	< 5	ppm	5	ppm Maximum
Organic Carbon	C	< 1	ppm	1	ppm Maximum

Performance Recovery of PMX Diaphragms

Can recover PMX Diaphragm performance if damaged by calcium, magnesium, iron, nickel, etc.

Clean PMX Diaphragm using inhibited hydrochloric acid.

SOME PROTECTIVE MEASURES FOR GOOD PERFORMANCE

Chemical Protection

- Protect against attack of sodium hypochlorite (NaOCl) on cathode screen;
- Use caustic soda (NaOH) + sodium sulfite (Na_2SO_3), during maintenance shutdowns;
- Use Cathodic Protection Rectifier.

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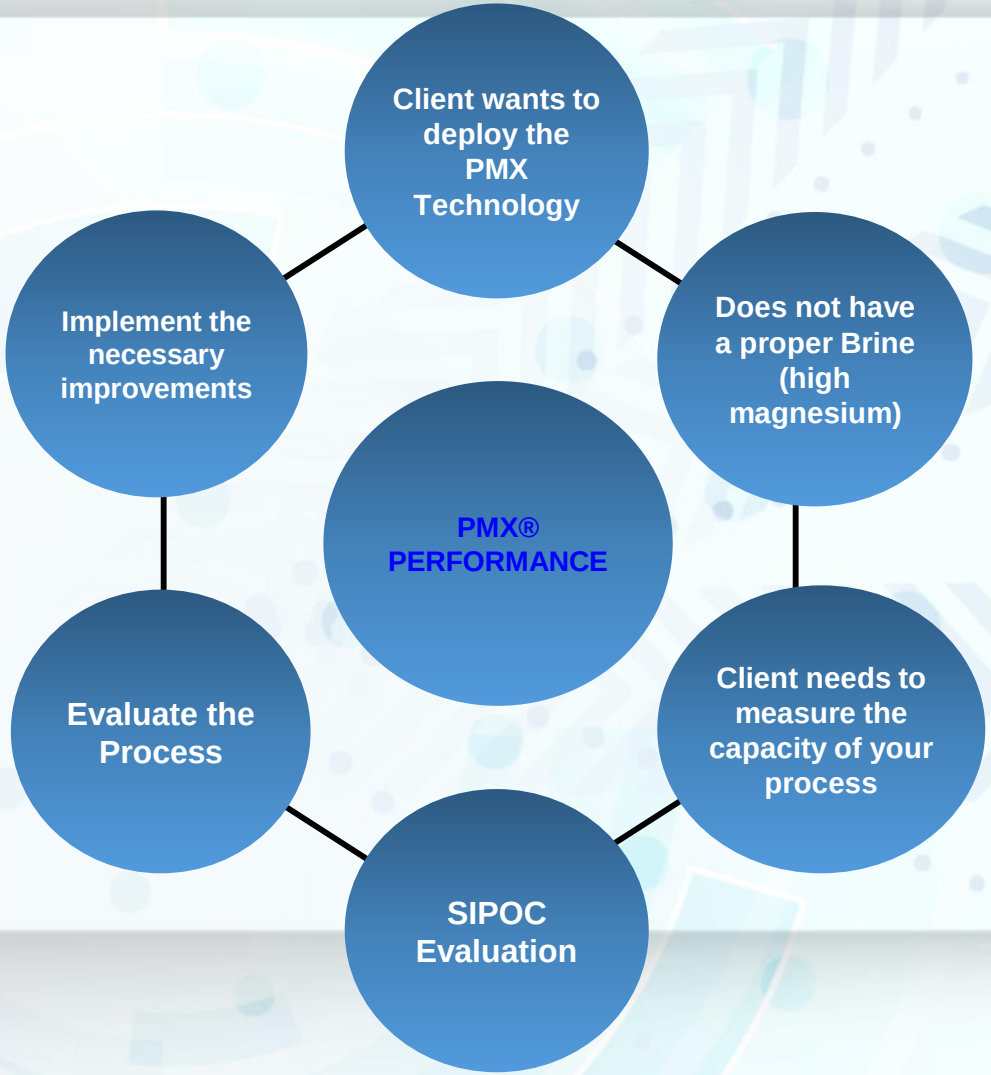
STUDY FOR IMPLEMENTATION PMX® DIAPHRAGM

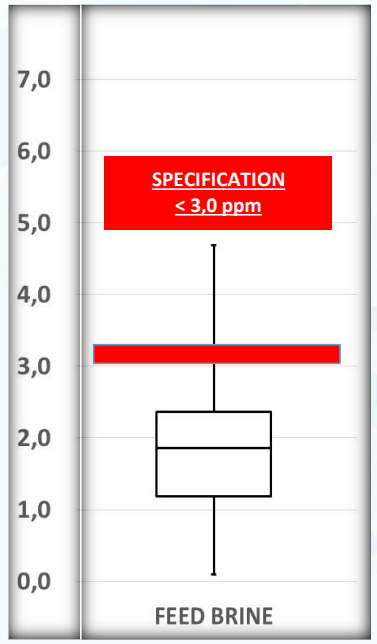


SIPOC (**S**uppliers, **I**nputs, **P**rocess, **O**utputs, **C**ustomers) is a visual tool for documenting a business process from beginning to end.

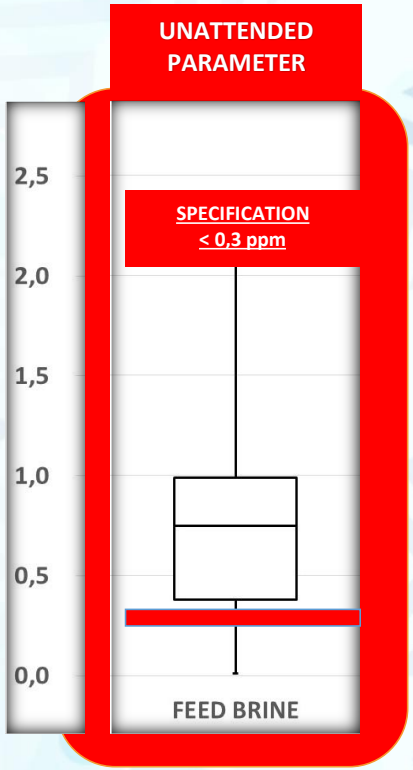
STUDY FOR IMPLEMENTATION PMX® DIAPHRAGM

- Operating data show values of "Hardness" Ca + Mg above recommended

BRINE HISTORY



Boxplot of Calcium (ppm)



Boxplot of Magnesium (ppm)

Specification of Feed Brine:

PARAMETER		TYPICAL	SPECIFICATION
Calcium	Ca	0.8 – 1.2 ppm	3.0 ppm Maximum
Magnesium	Mg	<0.1 ppm	0.3 ppm Maximum

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STUDY FOR IMPLEMENTATION PMX® DIAPHRAGM

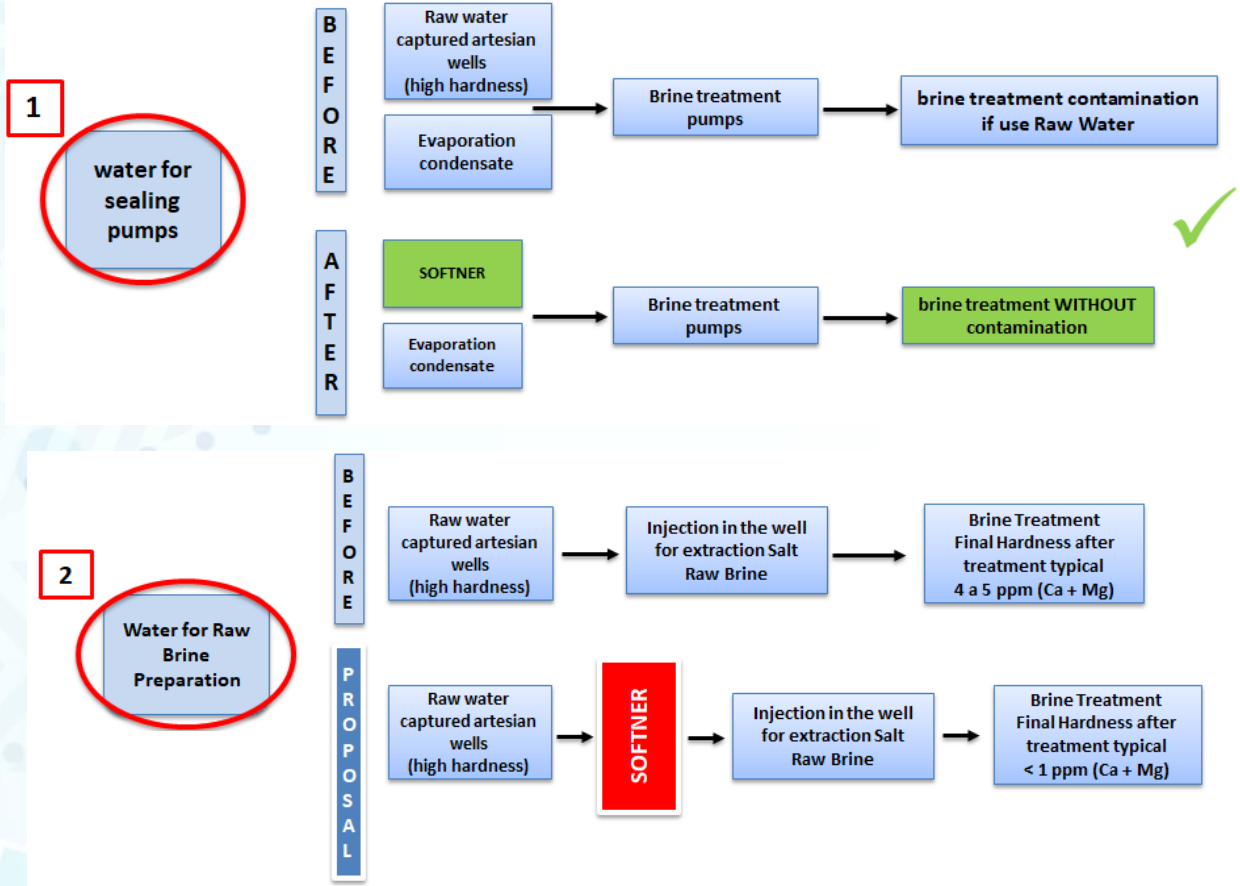
SOURCES OF HARDNESS AND SOLUTION PROPOSAL

1. WATER FOR SEALING PUMPS:

- **SOFTNER** system dedicated for sealing pumps and ressaturation.
- Implemented by **CUSTOMER**, as suggested by **DNB**.

2. WATER FOR THE PREPARATION OF RAW BRINE:

- **DNB** suggest installing a treatment for water used to prepare the raw brine (Reverse Osmosis or **SOFTNER**).



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STUDY FOR IMPLEMENTATION PMX® DIAPHRAGM

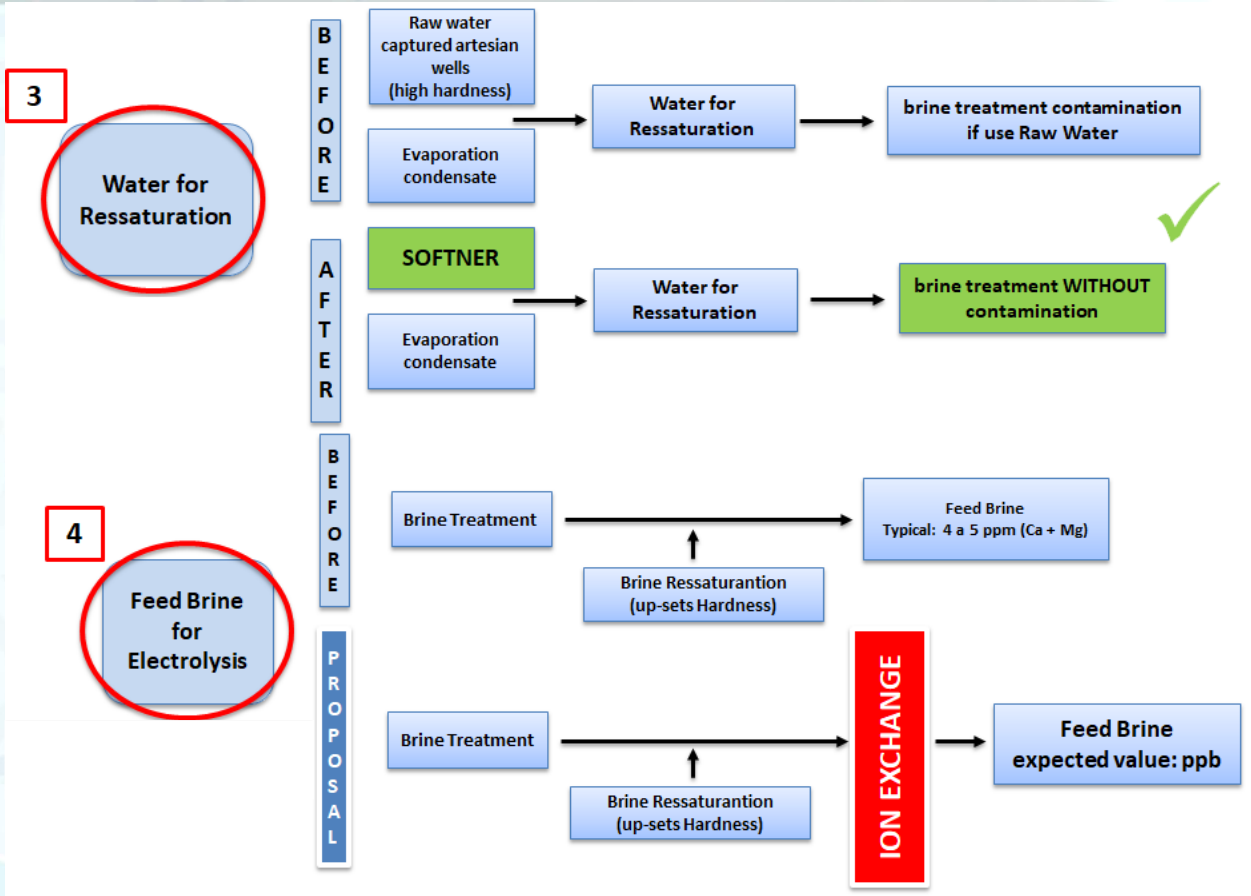
SOURCES OF HARDNESS AND SOLUTION PROPOSAL

3. WATER FOR RESSATURATION:

- Use of Evaporation primary condensate and if not, use water of **SOFTNER** system.
- If will use Raw Water, you have contamination of the Brine.

4. FEED BRINE FOR ELECTROLYSIS:

- **CUSTOMER** suggested the installation a **ION EXCHANGE**, ensuring a feed brine with low "Hardness"



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STUDY FOR IMPLEMENTATION PMX® DIAPHRAGM

BETTER ALTERNATIVES

PMX® DIAFRAGM: with the DNB recommendations, PMX implementation will achieve its best performance.

Less Impact

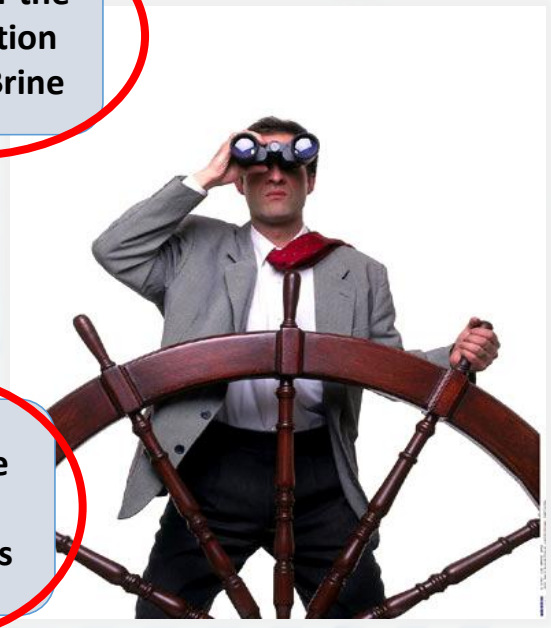
High Impact

2

Water for the preparation of Raw Brine

4

Feed Brine for Electrolysis



Reverse Osmosis

Softner / Ion Exchange

With the above alternatives, the water used in the brine preparation will not contribute to "Hardness" increasing.

Ion Exchange

Increased Investments and Complexity according to the level of automation

This is a solution as the ultimate protection barrier. If the brine treatment does not operate properly, the OPEX will be very high.

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PMX® PERFORMANCE – A SUCCESSFUL CASE WITH BRINE WITHIN THE SPECIFICATION

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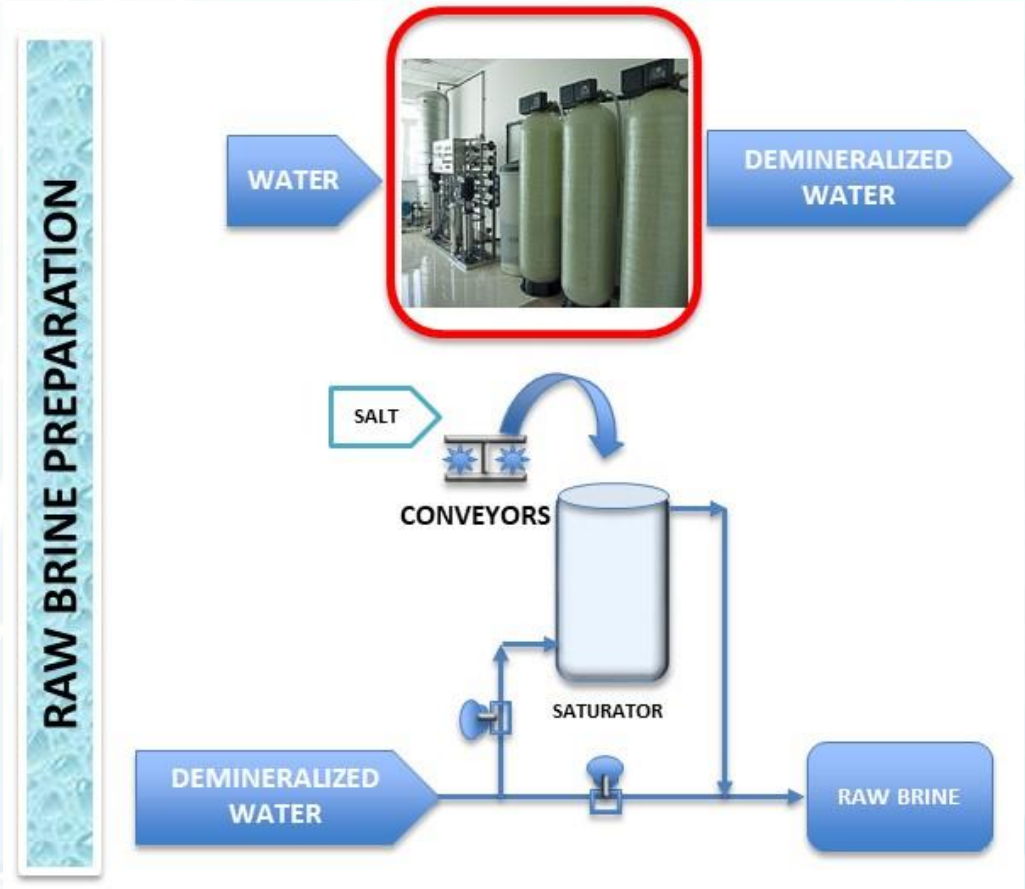
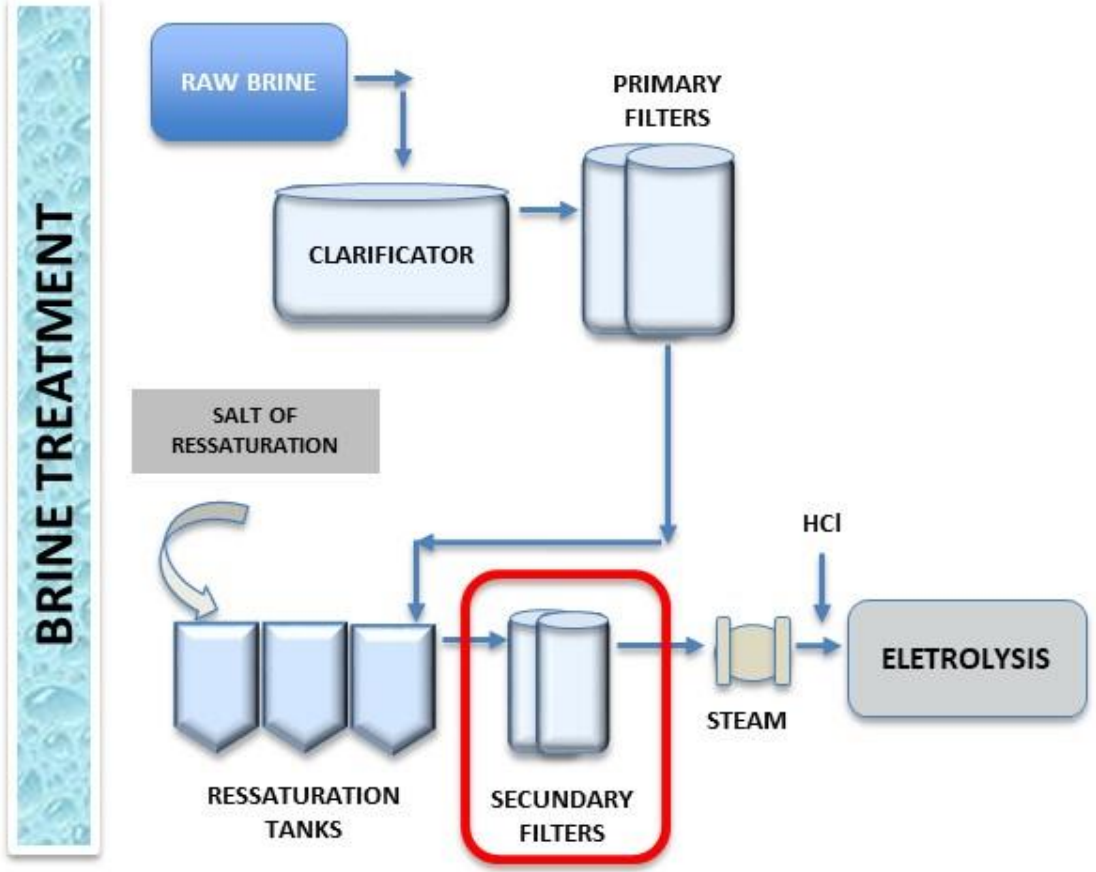
PROCESS FLOW CHART





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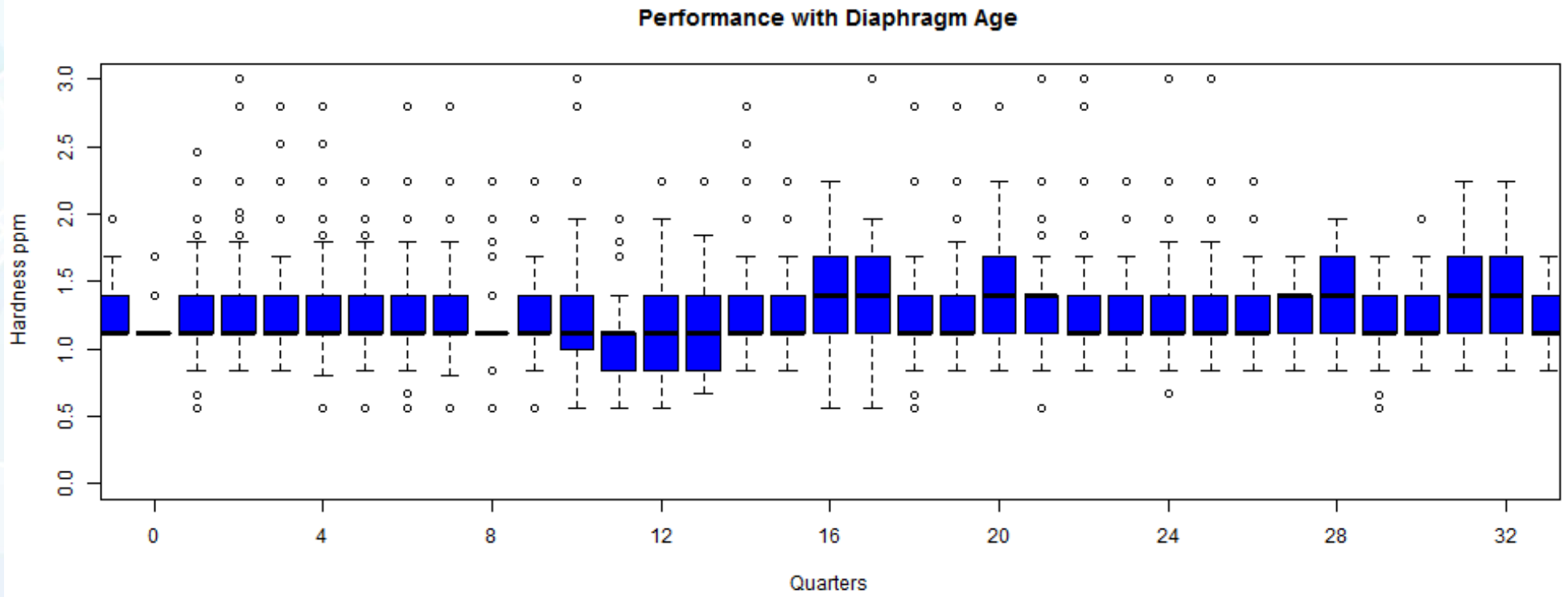
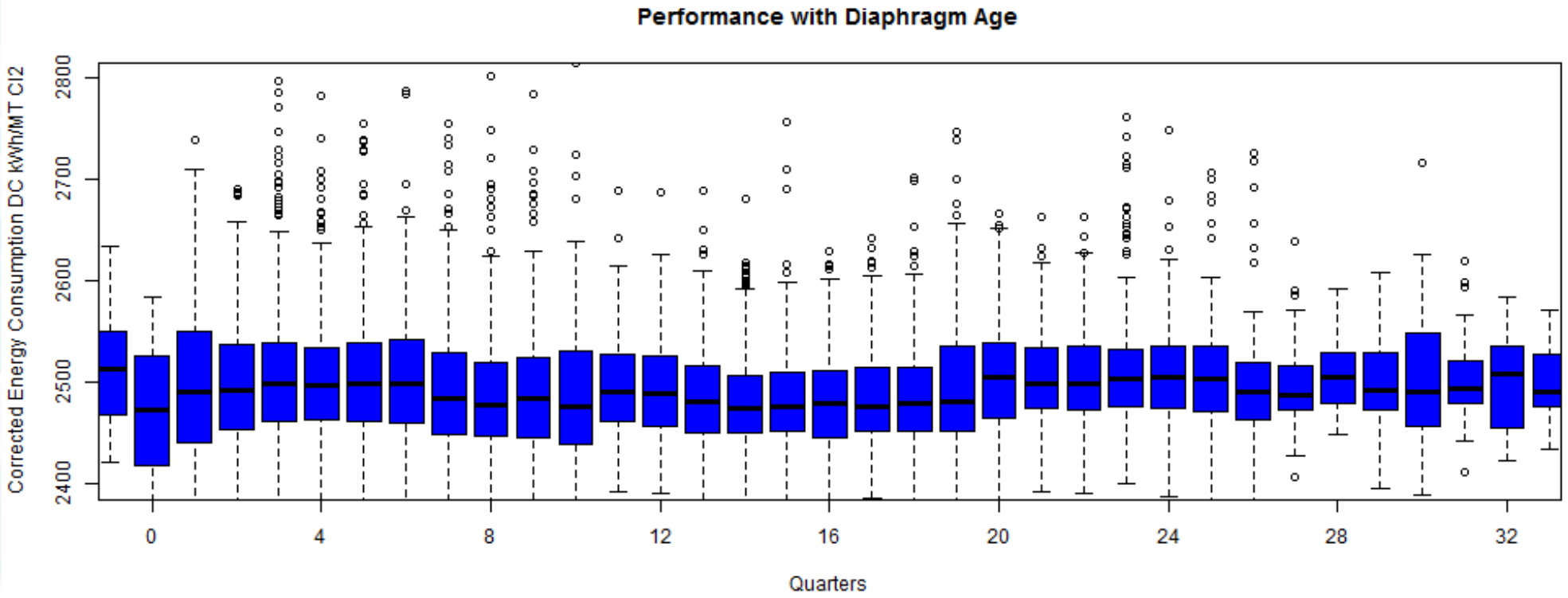
BRINE QUALITY



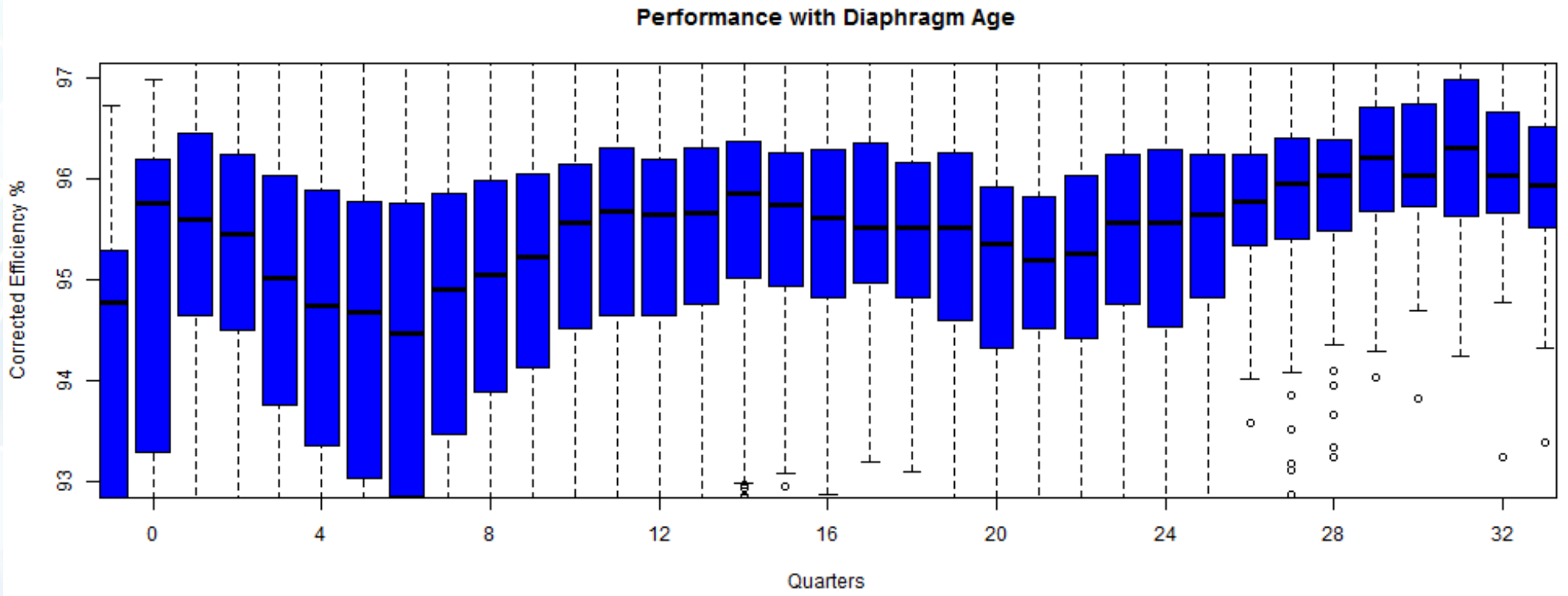
Brine hardness is the key: Mg in brine achieved <0.15 ppm using two-stage sand filter system

RESULTS ACHIEVED



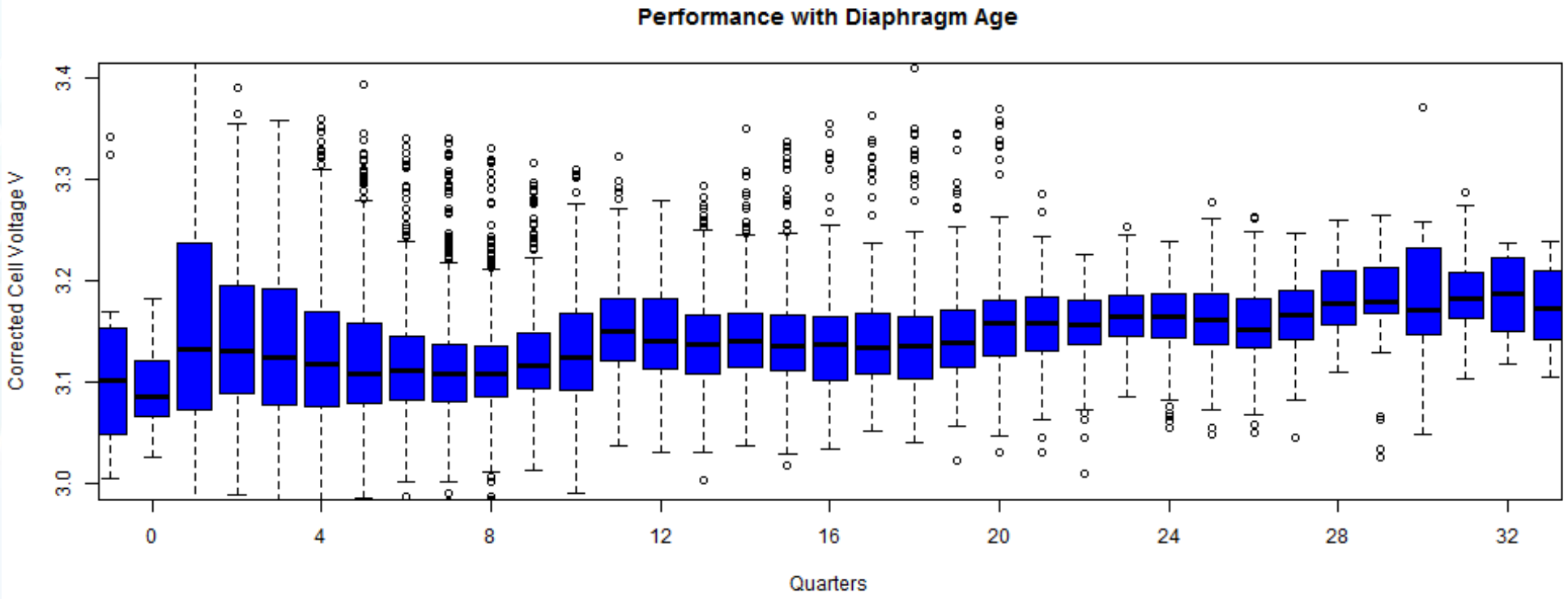
Stable performance over diaphragm age

RESULTS ACHIEVED



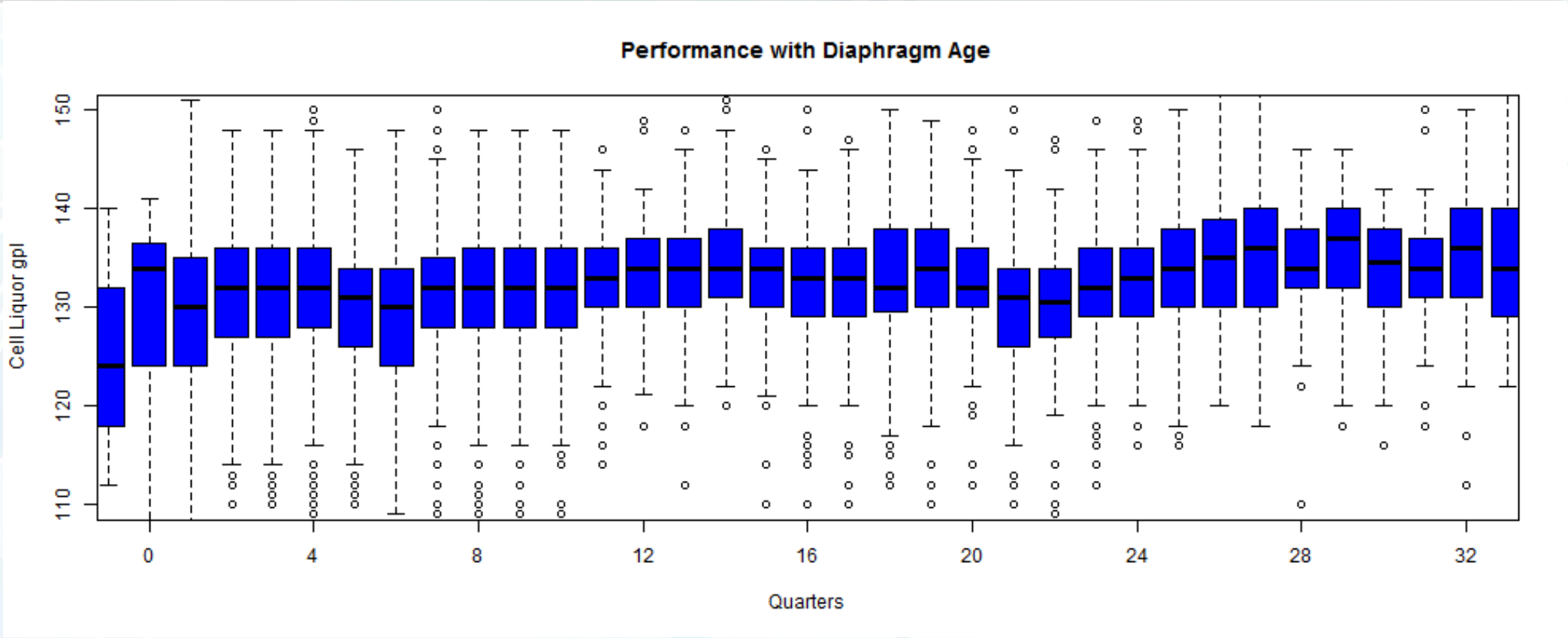
Stable performance over diaphragm age; reclaim frequency 6-8 quarters

RESULTS ACHIEVED



Stable performance over diaphragm age; coating age only as a slight factor

RESULTS ACHIEVED



CONCLUSIONS

CONCLUSIONS

- PMX Technology:
  - Lower power consumption compared to other technologies;
  - Long-lasting results, even with elderly Diaphragm;
  - Higher productivity with greater cell longevity;
  - Use of Environmentally Safe Technology.

- PMX Diaphragm life
  - PMX® expected life will be 5 years if Brine is kept within Specifications;
  - Successful outcome: ~ 39% of cells reach a life expectancy of more than 5 years;
  - ~ 6% cells achieved 11 years old.

Thank you for your attention

Questions?