

PENTAIR CARBON CAPTURE SOLUTIONS

CHALLENGES WITH INTERFACES

CCS and CO₂ Management – from Capture to Offshore Storage Capture
Hosted by DTU offshore

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14TH JUNE, 2022

Agenda

About Pentair

Carbon Capture Solutions

- Status of Pentair Carbon Capture Technology
- CCS Integration with CHP Plants
- CO₂ Quality for CCUS

Reference Projects

Test Results



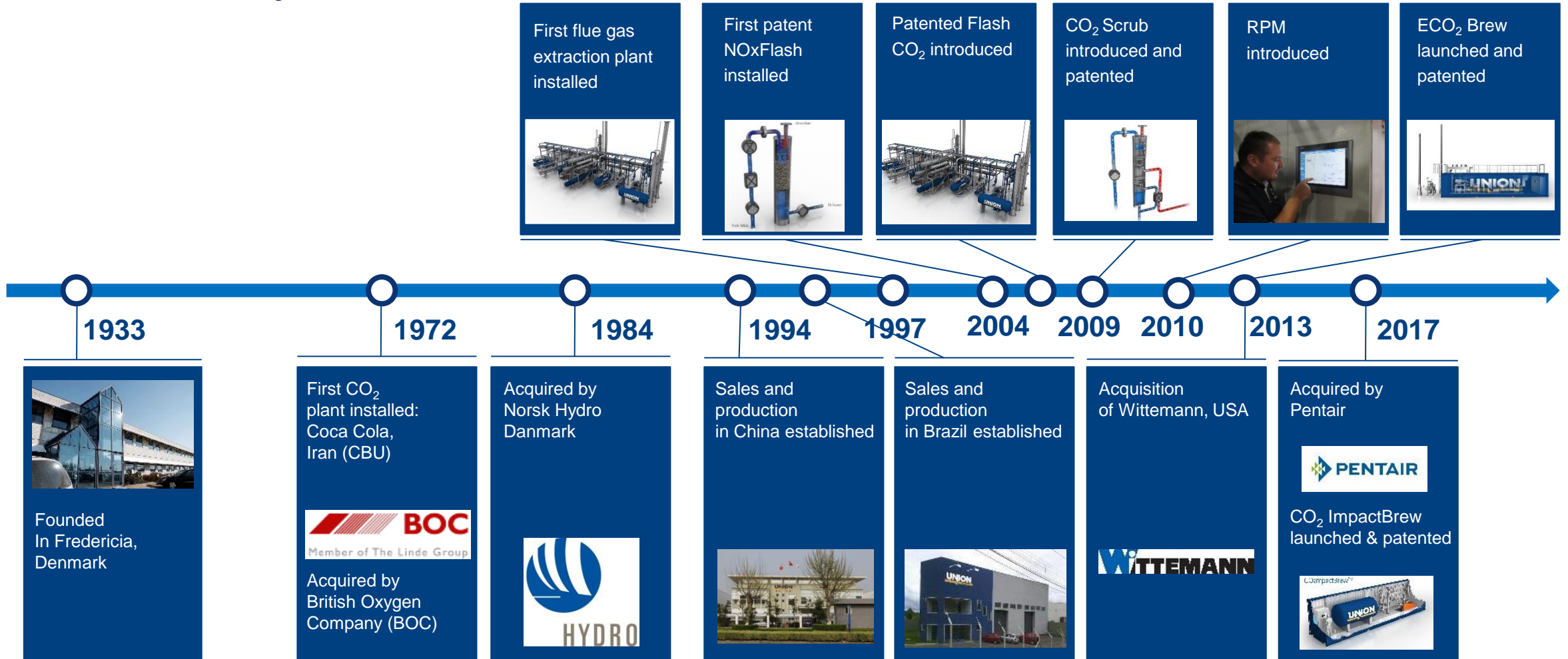


120 locations
In **25** countries
9,500 employees
8 business units
~\$3B in revenue

Mission:

“Deliver Smart,
Sustainable Solutions
that empower customers
to make the most of life’s
essential resources!”

Our history in short



Long history and knowledge of CO₂ technology

Pentair's contribution to decarbonization

CO₂ & METHANE PURIFICATION FROM BIOGAS

3 Stage & 2 Stage with CO₂
With Minimum Slip



75+

MEMBRANE
PLANTS

CO₂ CAPTURE FROM INDUSTRIAL PLANTS

500 lb to 15 ton/hr CO₂ Industrial CO₂
Anaerobic Digestion Biogas Upgrading



350+

AMINE PLANTS

CO₂ Plants for
Breweries &
Soft Drinks



2000+

CO₂ PLANTS

20,000+

MEASUREMENT
DEVICES



CO₂/O₂ in Breweries
BioSENSE



CO₂ RECOVERY IN BREWERIES/SOFT DRINKS

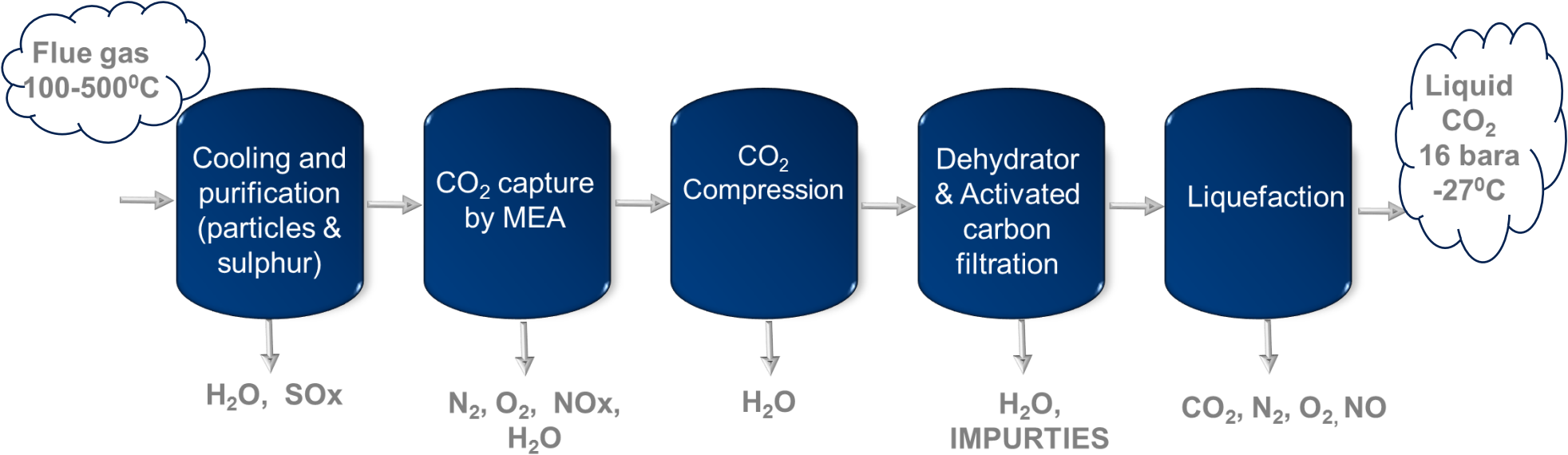
GAS ANALYSIS IN BREWERIES/SD/BIOGAS

Established provider in CO₂ Recovery and Biogas Solutions



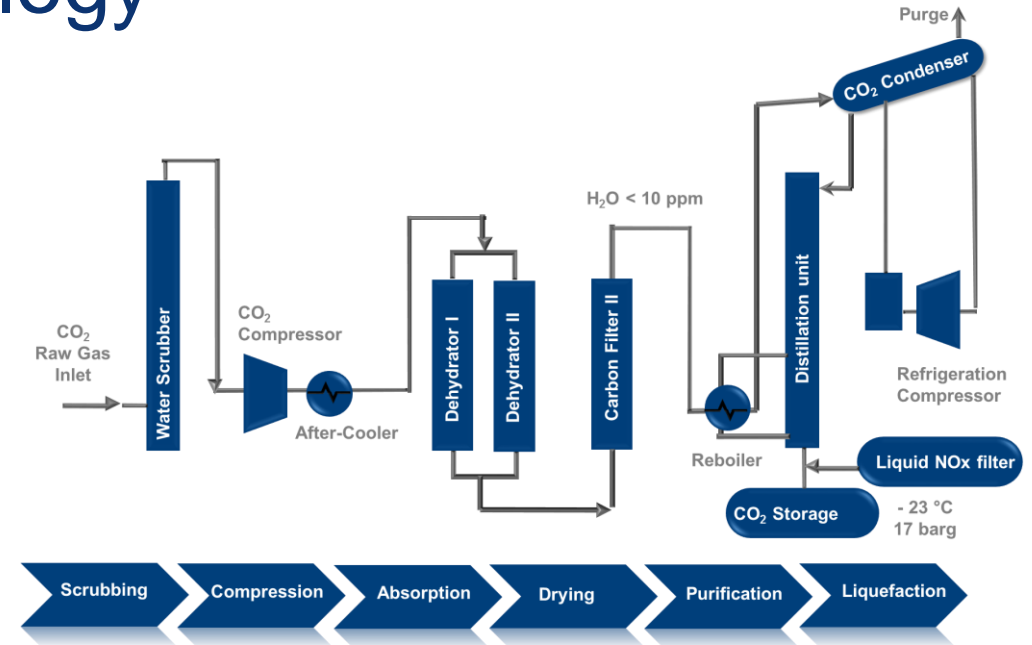
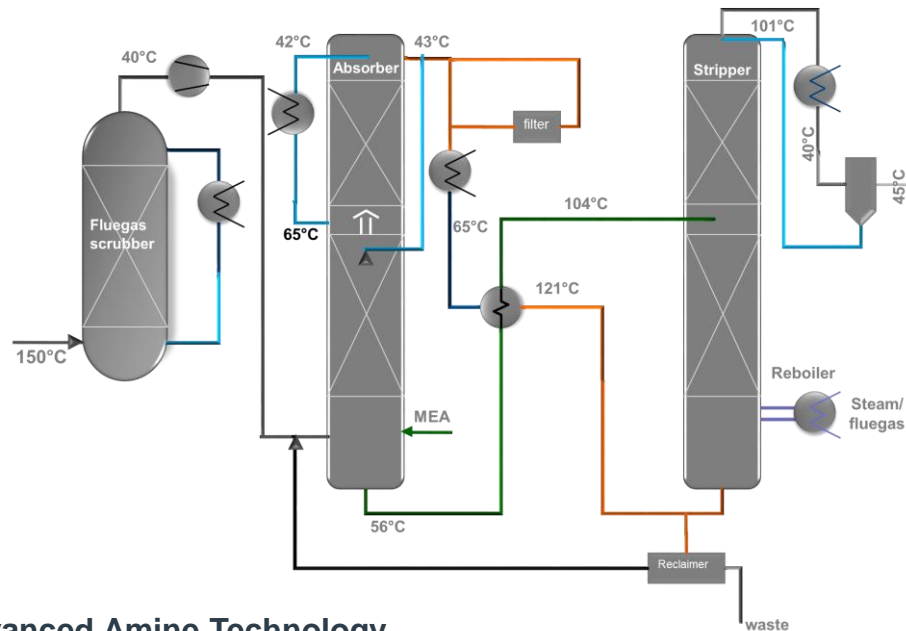
Status of Pentair Carbon Capture Technology

Advanced Amine Technology (AAT) - A Pentair Union Engineering Proprietary Technology



CO₂ Capture and Liquefaction – Process steps

Advanced Amine Technology (AAT) is a Pentair Union Engineering Proprietary Technology



Advanced Amine Technology

- AAT is mainly developed for Flue Gas CO₂ extraction and can be used for biogas upgrading.
- Designed for many different flue gas sources (power plants: fossil fueled, biomass fired, WtE, Cement, Lime Kilns etc.).
- Permits large scale CO₂ capture from low pressure, high oxygen containing flue gases.
- Based on the current most proven and efficient amine technology available on the market.
- Approved for beverage grade and meets CCU/S final product quality requirements.

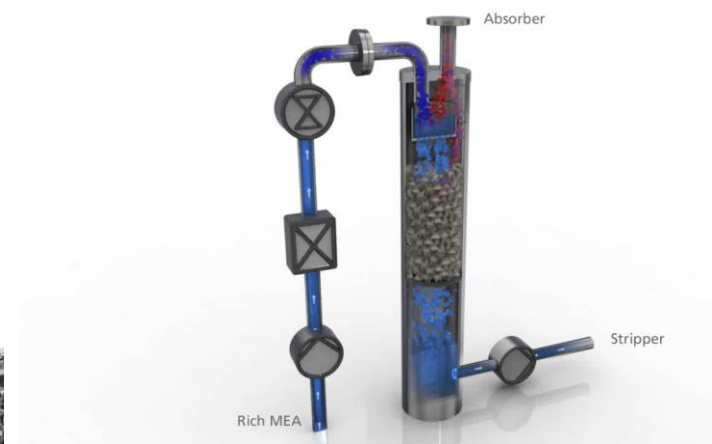
Pentair Union Engineering has more than 350 industrial scale amine plants in operation worldwide

Advanced Amine Technology (AAT), Advantages

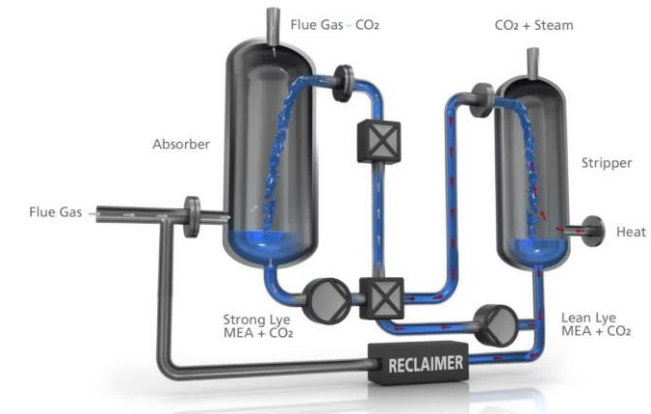
- All skid-mounted, modular solution
- High CO₂ reaction rate
- Tolerate high oxygen content (15%)
- Non-corrosive
- Higher CO₂ loading; approx factor 4
 - Lower circulation rates
- Nox-Flash, Propriety technology
- Reclaimer, Propriety technology
- Lower energy demand for re-generation
- Lower total energy demand
- New patented MVR technology for steam saving



Nox-Flash

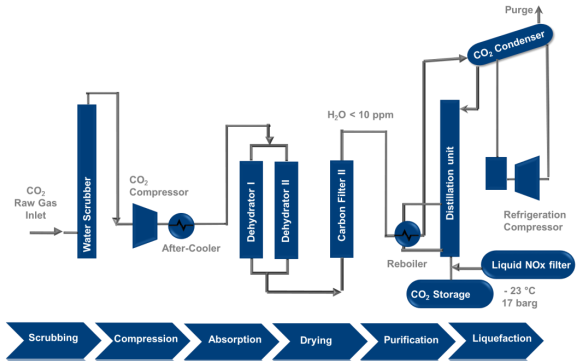
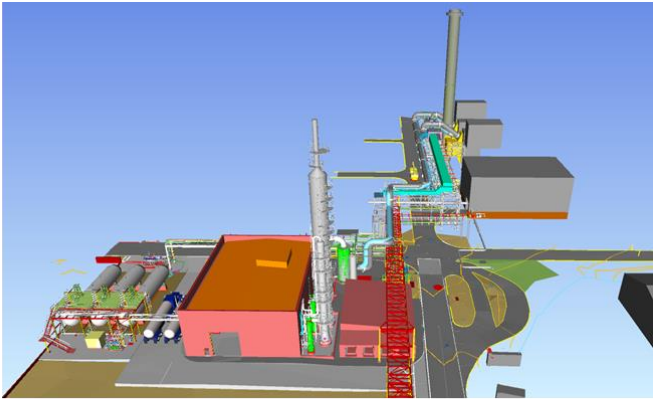
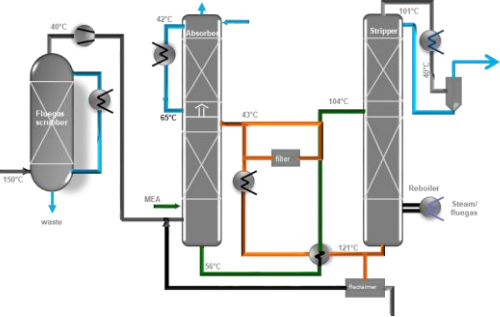


Reclaimer



The only Industrial Scale proven technology on the market

Carbon Capture & Utilization Plant, Tata Chemicals, Northwich, UK



115 tpd CO₂ is captured and utilized for on-site sodium bicarbonate production

Carbon Capture & Utilization Plant, Tata Chemicals, Northwich, UK



- 1st industrial scale CCU plant in the UK.
- Capturing 40,000 t of CO₂ from flue gases from on-site gas fired CHP plant, resulting in 11% carbon reduction.
- Captured CO₂ is liquefied, purified to highest standards and used for the manufacturing of high purity sodium bicarbonate.
- ‘Capture & Utilization’ presents true ‘circular economy’ opportunity and leads to one of the lowest carbon footprint sodium bicarbonate in the world.
- TCE CCU is mentioned for its valuable contribution towards net zero 2050 in UK government’s 10-point plan for the Green Industrial Revolution.

Largest carbon capture utilization plant built in the UK

Australia - Gas Fired Power Plant

- Installed in a very restrictive nature reserve.
- Conservation park at Torrens Island.
- Protected under National Parks and Wildlife Act 1972.
- Supplies beverage grade liquid CO₂ to the Merchant market.



More than 50,000 ton per year of CO₂ is captured and Liquefied

Spain - Biomass Fired Power Plant

- 150 tpd CO₂ capture capacity.
- Supply of both gaseous CO₂ for horticulture and liquid beverage grade CO₂.



More than 50.000 ton per year CO₂ will be captured soon

CCS INTEGRATION WITH CHP PLANTS

ARC CCS – CO₂ Capture Project



Partnership: EUDP Funding scheme under the Danish Energy Agency

Consortium:

- ARC Waste to Energy plant
- DTU Danish Technical University
- Ramboll Engineering company
- Pentair Technology provider



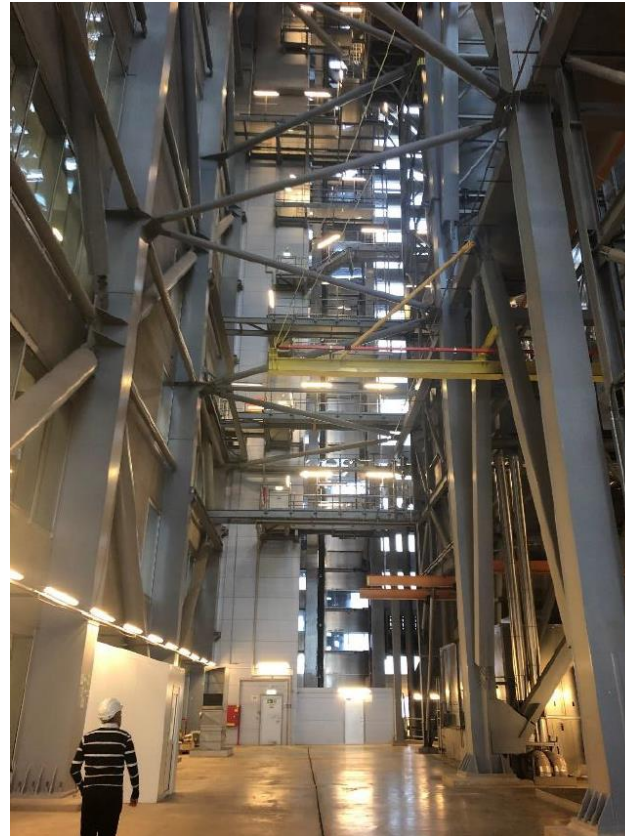
Pentair Union Engineering has supplied more than 350 Industrial Scale carbon capture plants worldwide.

ARC CCS

ARC Copenhagen/Denmark: Net Zero Carbon Capture

Pentair and ARC cooperation, a 3-step process to full scale Carbon Capture

1. Pilot plant completed. Multiple test results have been evaluated and will continue.
2. Demonstration plant of 160 kg/h is under delivery and will be commissioned during 2023.
3. Full scale of 500.000 t/y is planned in 2025.



ARC Copenhagen, Denmark

CO₂-Capture at ARC, WtE Power Plant

- 50 kg/h MEA extraction pilot plant installed.
- Prior to installation at ARC, it was used for testing on biogas.
- Why is Pentair involved:
- Plant is prepared for testing of other solvents.
- Integration of CC plant with Power Plant
- Integration in District Heating systems
- Support to DTU

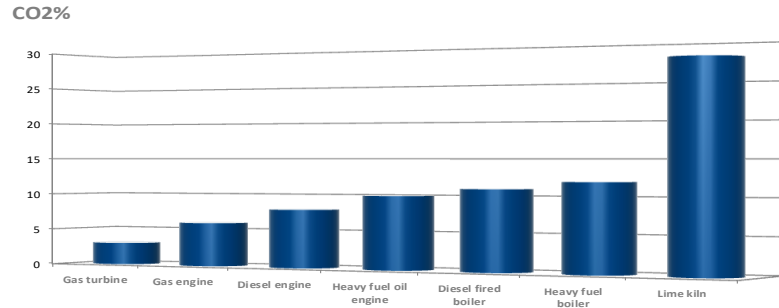


CO₂ Pilot Plant Installation

CO₂ Quality for CCUS

CO₂ quality for CCUS

Northern Light – specs



- Northern Light – specs
- Horticulture
- Beverage Grade
 - Exceed the EIGA and ISBT standards
- Electronic grade
- Extensive references from all sources such as...

COMPONENT	CONCENTRATION PPM (MOL)
Water, H ₂ O	≤ 30
Oxygen, O ₂	≤ 10
Sulphur oxides, SO _x	≤ 10
Nitric oxide, Nitrogen dioxide, NO _x	≤ 10
Hydrogen sulfide, H ₂ S	≤ 9
Carbon monoxide, CO	≤ 100
Amine	≤ 10
Ammonia, NH ₃	≤ 10
Hydrogen, H ₂	≤ 50
Formaldehyde	≤ 20
Acetaldehyde	≤ 20
Mercury, Hg	≤ 0.03
Cadmium, Cd	≤ 0.03
Thallium, Tl	(sum)

EIGA Specs. Food & Beverage grade

Parameter		Rationale ¹
Purity	99.9% v/v min.	Process
Moisture	20 ppm v/v max.	Process
Acidity	To pass test	Regulatory
Oxygen	30 ppm v/v max.	Sensory
Nitrogen compounds		
Ammonia	2.5 ppm v/v max.	Process
Nitric oxide/nitrogen dioxide	2.5 ppm v/v max. each	Regulatory
Non-volatile residue	10 ppm w/w max.	Sensory
Non-volatile organic residue	5 ppm w/w max.	Sensory
Phosphine	To pass test (0.3 ppm v/v max)	Regulatory
Total volatile	50 ppm v/v max. of which 20 ppm v/v	Sensory
Hydrocarbons (as methane)	max. of non-methane hydrocarbons	
Acetaldehyde	0.2 ppm v/v max.	Sensory
Aromatic hydrocarbon	0.020 ppm v/v max.	Regulatory
Carbon monoxide	10 ppm v/v max.	Process
Total sulfur (as S)	0.1 ppm v/v max.	Sensory
Carbonyl sulfide	0.1 ppm v/v max.	Sensory
Hydrogen sulfide	0.1 ppm v/v max.	Sensory
Sulfur dioxide	1 ppm v/v max.	Sensory
Appearance in water	No color or turbidity	Sensory
Odor	Odorless	Sensory
Taste and odor	No foreign taste or odor in water	Sensory

Table 1. ISBT Carbon Dioxide Guidelines.

¹Rationale definitions:

Sensory: Any attribute that negatively impacts the taste, appearance, or odor of beverage.

Process: Any attribute that defines a key parameter in a controlled process and an important consideration in the beverage industry.

Regulatory: Any attribute whose limit is set by governing regulatory agencies.

CO₂ quality

Proven Technologies – Process Quality - Testing at ARC

- Stress testing of technologies
- Heat integration
- Testing of MEA solvent
- Testing of alternative solvents
- Specific Reboiler Duty
- Total cost of ownership
 - Open-source solvents vs Propriety solvents
 - Up-time vs unforeseen shut-downs
 - What if final product quality cannot be achieved?
 - What if process design flaws cannot be rectified?
- Why foaming?
 - With wrong design even anti-foaming agent has no impact



Pentair AAT advanced MEA plants is the only proven technology for short to mid-term CO₂ Extraction



THANK YOU FOR YOUR
KIND ATTENTION