# $CO_2$ Dehydration Product Offerings

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# $CO_2$ Dehydration Overview

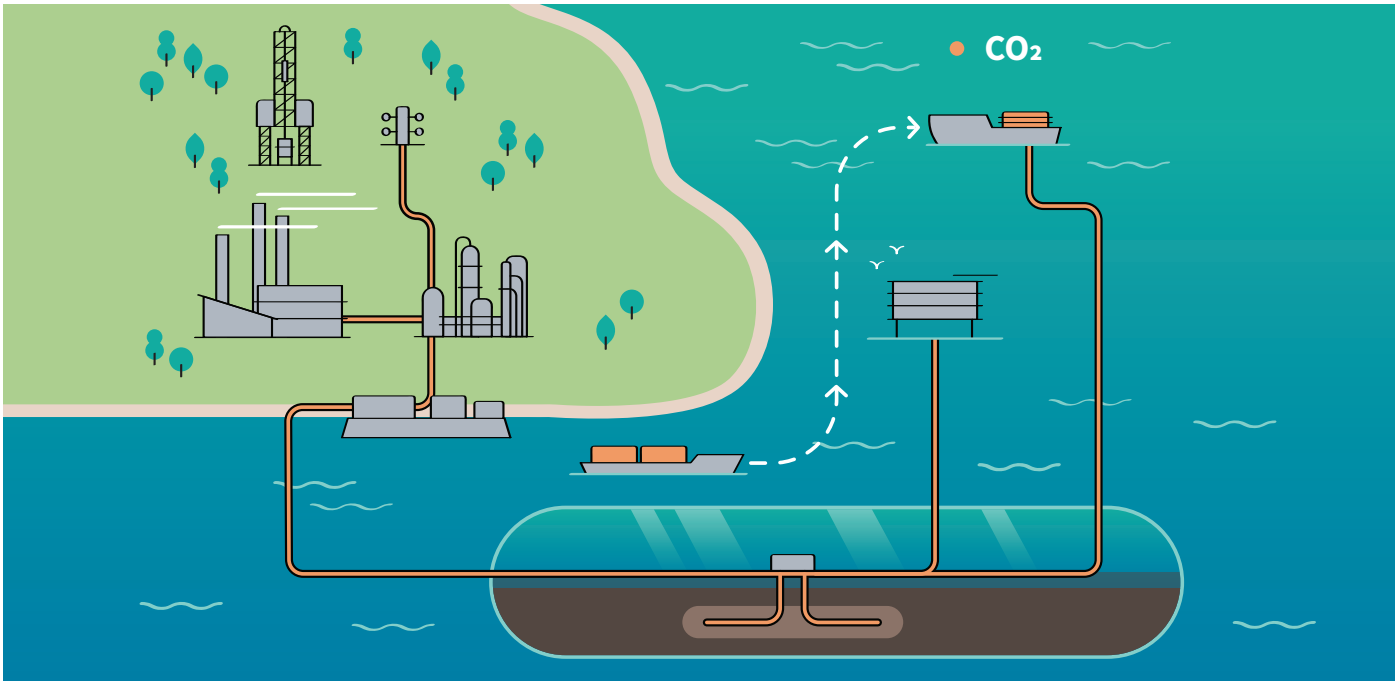
Carbon capture processes typically result in wet $CO_2$ gas streams that require further processing to meet transportation and storage specifications. The presence of water in $CO_2$ creates carbonic acid, a very corrosive fluid that, when left untreated, can cause severe corrosion to carbon steel metallurgy common in pipelines, pump stations, and storage facilities.

Dehydration is a critical step that involves the removal of water vapor from the $CO_2$ gas stream. $CO_2$ dehydration plays a crucial role in enabling the effective and safe transportation of $CO_2$ from capture facilities to storage sites. Implementing efficient dehydration technologies will enhance the viability of CCS projects.

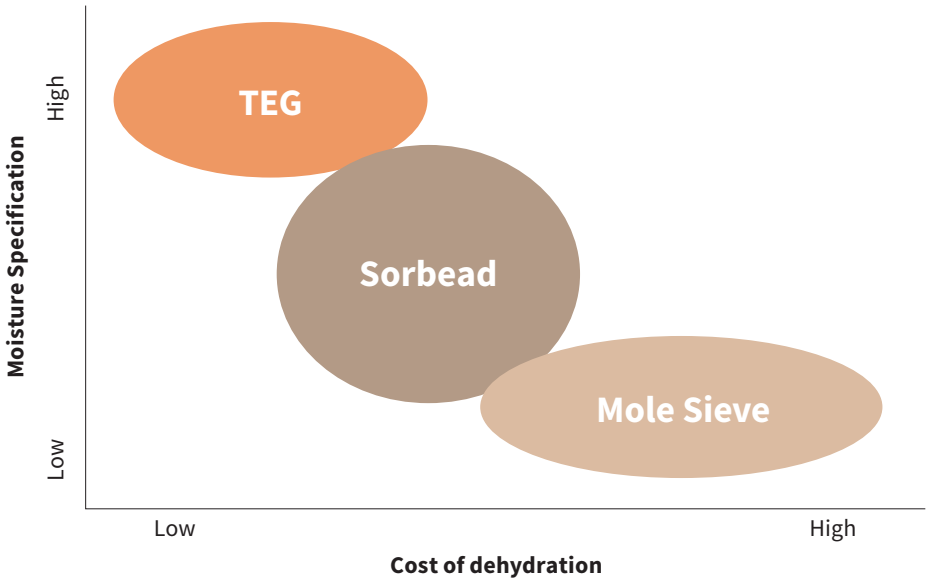
There are a variety of proven and mature $CO_2$ dehydration technologies that can be deployed to meet gas specifications for $CO_2$ transportation. Each comes with its own set of advantages and challenges. The selection of $CO_2$ dehydration technology will depend on several factors, including the $CO_2$ source, operational scale, energy requirements, cost considerations, and water content specifications for transport and injection well. Each application and method of $CO_2$ transportation, whether by pipeline, truck, rail, or ship, will require different water content and gas purity specifications (see table below).

As a leading global provider of CO2 dehydration technology and equipment, NOV has expertise in deploying $CO_2$ dehydration systems throughout the world. We can help you assess which technology best suits any given application.

| | **Pipeline** | **Medium Pressure Shipping** | **Low Pressure Shipping** | **Rail / Truck** |
|---|---|---|---|---|
| **$CO_2$ Phase** | Liquid (Supercritical) | Liquid | Liquid | Liquid |
| **$CO_2$ Temperature** | Ambient | -30°C | -50°C | -18°C |
| **Typical $CO_2$ Pressure** | 100-150 bar | 15 bar | 6.5 bar | 14-20 bar |
| **Typical Water Specification** | 100-400 ppmv | <30 ppmv | <5 ppmv | <30 ppmv |
| **Typical Oxygen Specification** | <10 ppmv | <10 ppmv | <10 ppmv | <10 ppmv |



# $CO_2$ Dehydration Technologies




## Triethylene Glycol Dehydration

Triethylene glycol (TEG) is an absorption-based gas dehydration method that uses a liquid solvent to selectively absorb water from the $CO_2$ stream. It is known for its high dehydration efficiency and commercial viability. Known for its high efficiency, commercial viability, and cost-effectiveness, TEG results in a relatively higher water content level than other dehydration technologies. It is typically recommended for water content specifications down to 50 ppmv.

## BASF Sorbead Dehydration

BASF Sorbead® technology is a temperature swing adsorption process that involves passing the $CO_2$ gas stream through a Sorbead aluminosilicate gel bed, which has a high affinity for water molecules. The Sorbead system is then regenerated through heat. It offers a relatively low energy, low cost, and simple method for dehydration. The ease of regenerating the Sorbead bed in a cyclic manner while achieving low water content in the dried $CO_2$ makes this process appealing. Sorbead dehydration is typically recommended for 5 to 50 ppmv water content specifications.

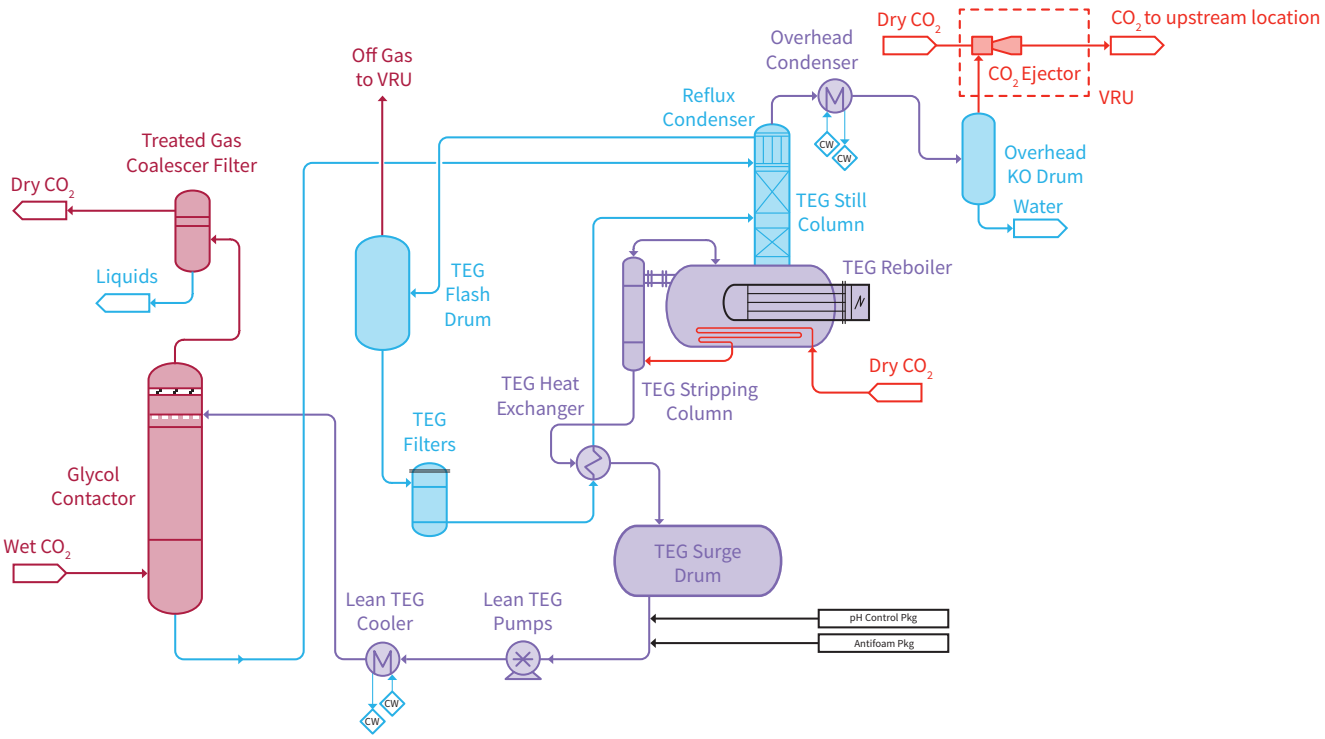
## Molecular Sieve Dehydration

Molecular sieve temperature swing adsorption technology employs zeolite microporous structures that selectively adsorb water molecules based on size and polarity. The dehydration process involves the adsorption of water molecules onto the surface of the molecular sieve material. Molecular sieve systems are regenerated by using heat to desorb the water molecules. The ease of regenerating the molecular sieve in a cyclic manner while achieving very low water content in the dried $CO_2$ makes this process appealing for certain applications. Molecular sieve technology can achieve very dry $CO_2$ gas, which is beyond what is typically required for various CO2 transport methods and is more expensive than the other technologies. It is typically recommended for <1 ppmv water content specifications.

# Triethylene Glycol Dehydration

Triethylene glycol (TEG) is an absorption-based gas dehydration method that uses a liquid solvent to selectively absorb water from the $CO_2$ stream. Known for its high dehydration efficiency, commercial viability, and cost-effectiveness, TEG results in a higher water content level than the other technologies. TEG dehydration systems can dehydrate gas streams typically down to 50 ppmv water content specifications.

## TEG Dehydration at a glance

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## Our Glycol Dehydration offering:

- Meets the $CO_2$ dryness specifications of you project
- Stick-built and modularized options
- Compact TEG (Super Purifier)
- Provides the lowest OPEX solution for long-term operation
- Flexible design for dehydration efficiency
- Incorporates health, safety, and environmental control

We offer efficient and optimized process design, fabrication, and package delivery for CO2 dehydration systems. Whether using a full-scope or split-scope approach, we are comfortable working with EPCs, project developers, and consortium arrangements to meet various project requirements. Our direct relationships with key EPC companies, midstream/sequestration companies, and CCUS developers enable us to offer a complete turnkey solution.

## Glycol Dehydration

- **Typical $CO_2$ flow capacity:** ~10 to 5000 ktpa $CO_2$
- **$CO_2$ water inlet composition:** ~saturated
  - Flexible composition
- **Technology:** Glycol solvent based technology (TEG)
- **Typical glycol flow rate:** 1-18 $m^3/h$ (cubic meter per hour)
- **Constructability:** Customizable or standardized module

## Notable features for $CO_2$ Glycol Dehydration:

- Suitable for water dryness down to 50 ppmv (2.5 lb/MMSCF)
  - <50 ppmv (2.5 lb/MMSCF) evaluated on case-to-case basis
- Stripping agent either dry $CO_2$ or nitrogen
- Vapor recovery units (VRU) to recover off-gas $CO_2$ to eliminate emissions
- Qualified for onshore and offshore applications

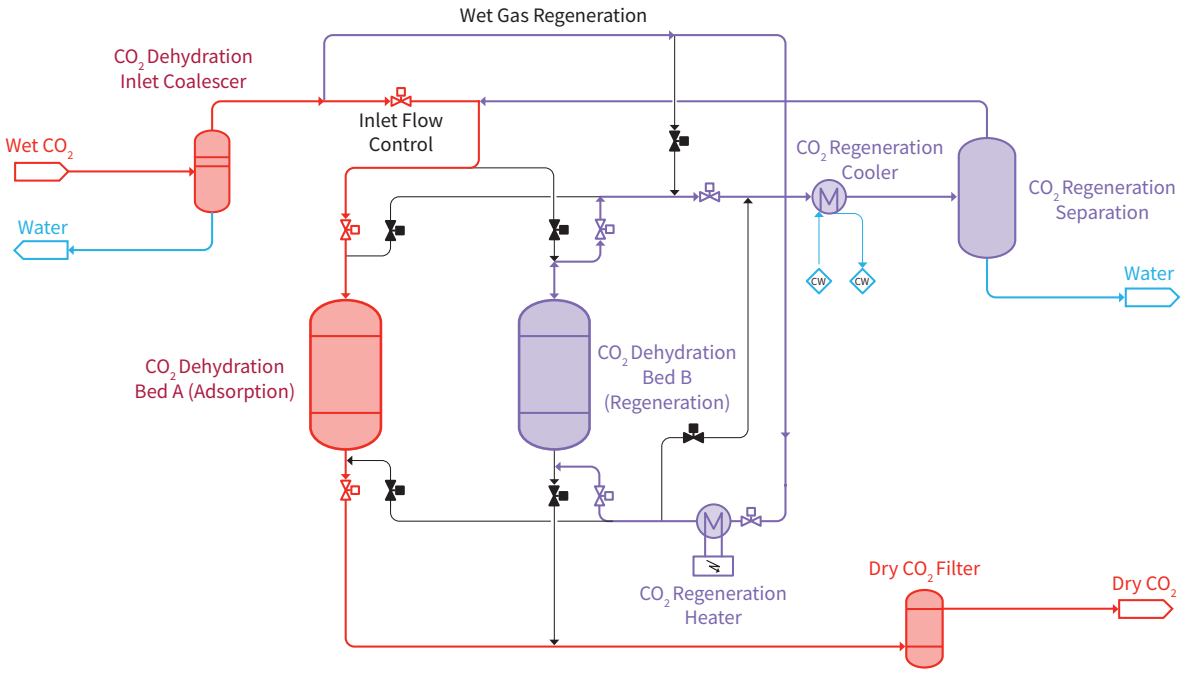
## Standardized TEG offerings:

- **STG-1** – 1000 kg/h Lean TEG
- **STG-2** – 2000 kg/h Lean TEG
- **STG-4** – 4000 kg/h Lean TEG
- **STG-6** – 6000 kg/h Lean TEG
- **STG-9** – 9000 kg/h Lean TEG

# BASF Sorbead Dehydration

BASF Sorbead® technology is a temperature swing adsorption (TSA) process that involves passing the $CO_2$ gas stream through a Sorbead aluminosilicate gel bed, which has a high affinity for water molecules. The Sorbead system is then regenerated through heat. It offers a relatively low energy, low cost, and simple method for dehydration. The ease of regenerating the Sorbead bed in a cyclic manner while achieving low water content in the dried $CO_2$ makes this process appealing. Sorbead dehydration is typically recommended for 5 to 50 ppmv water content specifications.

## TSA with wet gas regeneration at a glance

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## Our BASF Sorbead offering:

- Meets the $CO_2$ dryness specifications of your project
- Customized, stick-built solutions for the most challenging projects
- Standardized modularized solutions for fast deployment
- Wet gas regeneration or dry gas regeneration configuration to meet the needs of your project
- Provides the lowest OPEX solution for long-term operation
    - Lower regeneration temperatures compared to molecular sieves
    - Longer bed life compared to molecular sieves
- Smart Bed™ digital solution
- Flexible design for dehydration efficiency, pressure drop, and turndown ratios
- Incorporates health, safety, and environmental control

We offer efficient and optimized process design, fabrication, and package delivery for CO2 dehydration systems. Whether using a full-scope or split-scope approach, we are comfortable working with EPCs, project developers, and consortium arrangements to meet various project requirements. Our direct relationships with key EPC companies, midstream/sequestration companies, and CCUS developers enable us to offer a complete turnkey solution.

## BASF Sorbead offering

- **Typical $CO_2$ flow capacity:** ~10 to 5000 ktpa $CO_2$
- **$CO_2$ water inlet composition:** ~saturation
    - Flexible composition
- **Technology:** TSA with aluminosilicate gel-based adsorbent
- **Constructability:** Customizable stick-built or modular

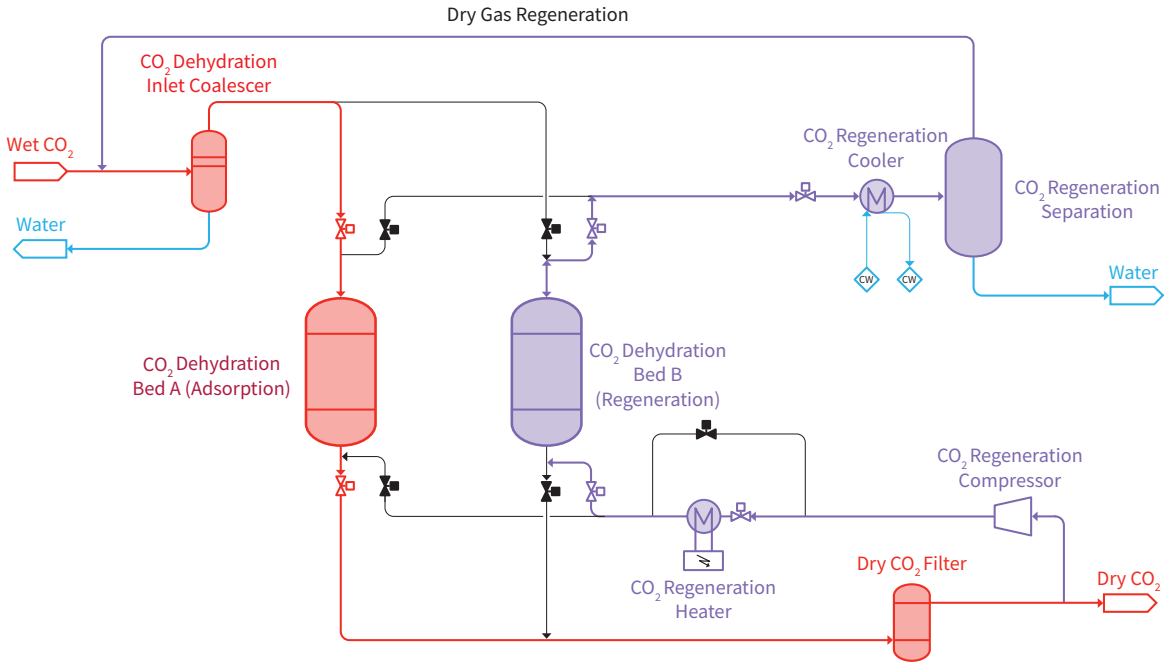
## Notable features for TSA with BASF Sorbead:

- Suitable for water dryness down to 5 ppmv (0.25 lb/MMSCF)
    - <5 ppmv (0.25 lb/MMSCF) evaluated on case-to-case basis
- Acid resistant
- Fast start-up times
- High turndown ratios
- Inherently emissions free
- Onshore and offshore designs

# Molecular Sieve Dehydration

Molecular sieve temperature swing adsorption (TSA) technology employs zeolite microporous structures that selectively adsorb water molecules based on size and polarity. The dehydration process involves the adsorption of water molecules onto the surface of the molecular sieve material. Molecular sieve systems are regenerated by using heat to desorb the water molecules. The ease of regeneration in a cyclic manner of molecular sieve while achieving low water content in the dried $CO_2$ gas stream makes this process a very appealing solution when low water specifications exist. Molecular sieve technology can achieve very dry $CO_2$ gas, which is beyond what is typically required for various CO2 transport methods and is more expensive than the other technologies. It is typically recommended for <1 ppmv water content specifications.

## TSA with dry gas regeneration at a glance

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## Our Molecular Sieve offering:

- Meet the $CO_2$ dryness specifications of your project
- Customized, stick-built solutions for the most challenging projects
- Standardized modularized solutions for fast deployment
- Wet gas regeneration or dry gas regeneration configuration to meet the needs of your project
- Provide the lowest dryness requirements
- Smart Bed™ digital solution
- Flexible design for dehydration efficiency
- Incorporates health, safety, and environmental control

We offer efficient and optimized process design, fabrication, and package delivery for CO2 dehydration systems. Whether using a full-scope or split-scope approach, we are comfortable working with EPCs, project developers, and consortium arrangements to meet various project requirements. Our direct relationships with key EPC companies, midstream/sequestration companies, and CCUS developers enable us to offer a complete turnkey solution.

## Molecular Sieve offering

- **Typical $CO_2$ flow capacity:** ~10 to 5000 ktpa $CO_2$
- **$CO_2$ water inlet composition:** ~saturation
  - Flexible composition
- **Technology:** TSA with molecular sieve
- **Constructability:** Customizable stick-built or modular

## Notable features for TSA with Molecular Sieve:

- Suitable for water dryness down to 1 ppmv (0.05 lb/MMSCF)
  - <1 ppmv (0.05 lb/MMSCF) evaluated on a case-by-case basis
- Acid resistant
- Fast start-up times
- Inherently emissions free
- Onshore and offshore designs

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