CO_2 Dehydration Product Offerings

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CO_2 Dehydration Overview

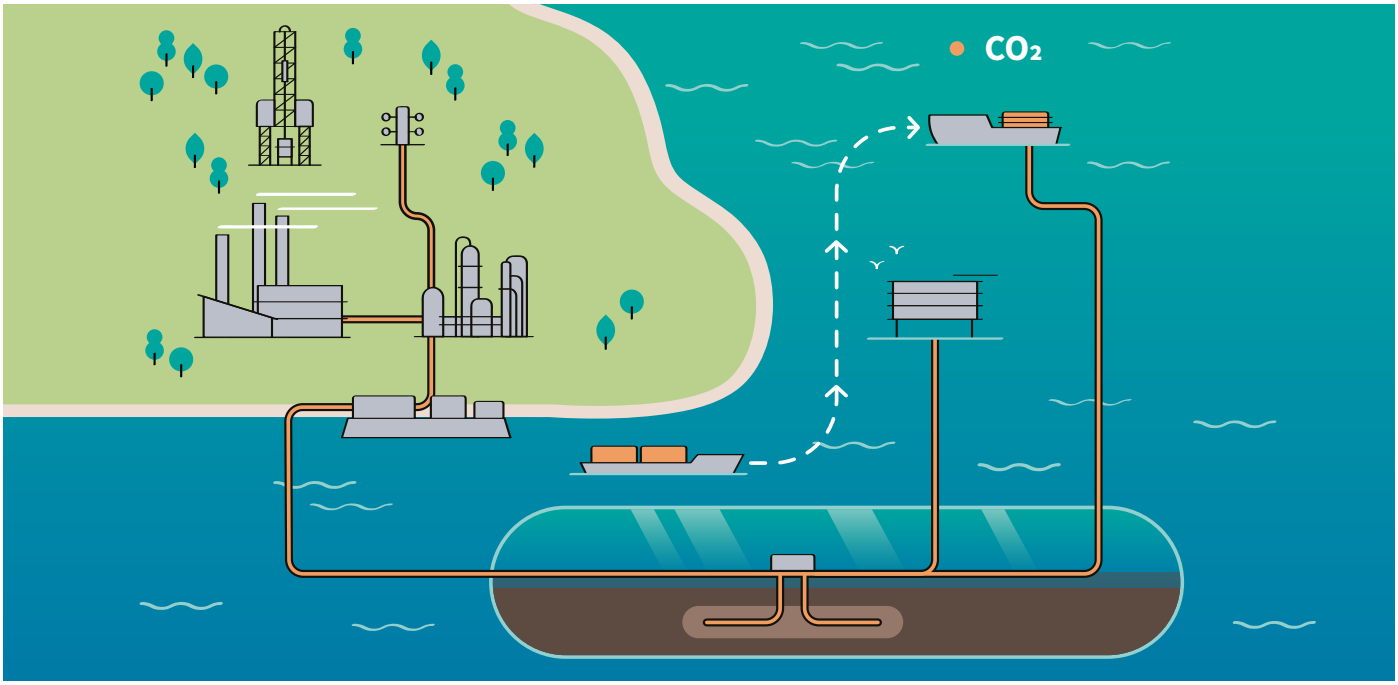
Carbon capture processes typically result in wet CO_2 gas streams that require further processing to meet transportation and storage specifications. The presence of water in CO_2 creates carbonic acid, a very corrosive fluid that when left untreated can cause severe corrosion to carbon steel metallurgy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

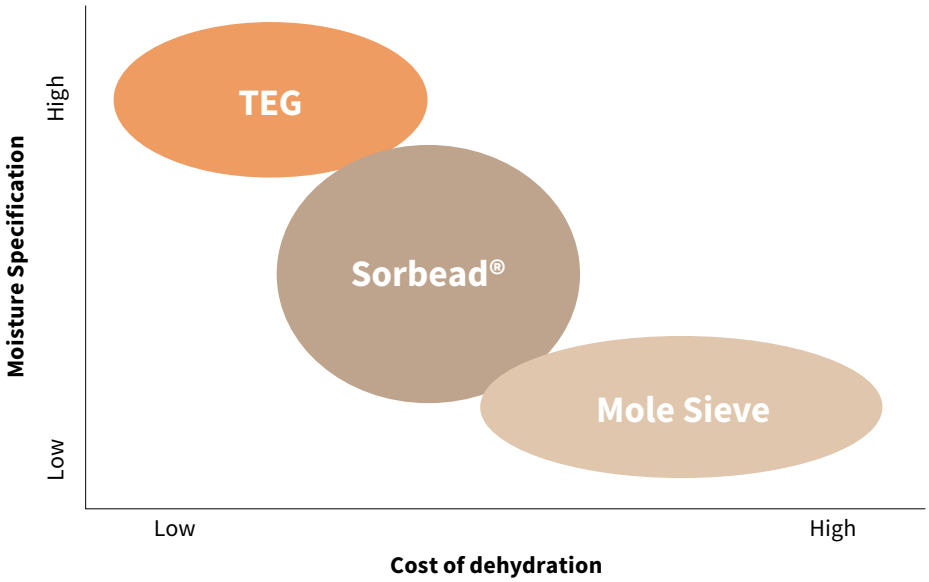
There are a variety of proven and mature CO_2 dehydration technologies that can be deployed to meet gas specifications for CO_2 transportation, each with its own set of advantages and challenges. The selection of CO_2 dehydration technology will depend on several factors, including the CO_2 source, operational 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 specifications for water content and gas purity (see table below).

As a global leader in CO_2 dehydation technology and equipment provider, NOV has particular expertise in deploying CO_2 dehydration systems throughout the world and can help you assess which technology is best suited for 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 to 150 bar	15 bar	6.5 bar	14-20 bar
Typical Water Specification	100-400 ppmv H_2O	<30 ppmv H_2O	<5 ppmv H_2O	<30 ppmv H_2O
Typical Oxygen Specification	<10 ppmv O_2	<10 ppmv O_2	<10 ppmv O_2	<10 ppmv O_2



CO_2 Dehydration Technologies



Glycol (TEG) Dehydration

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

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 make this process a very appealing solution. Sorbead dehydration is typically recommended for 5 to 50 ppmv water content specifications.

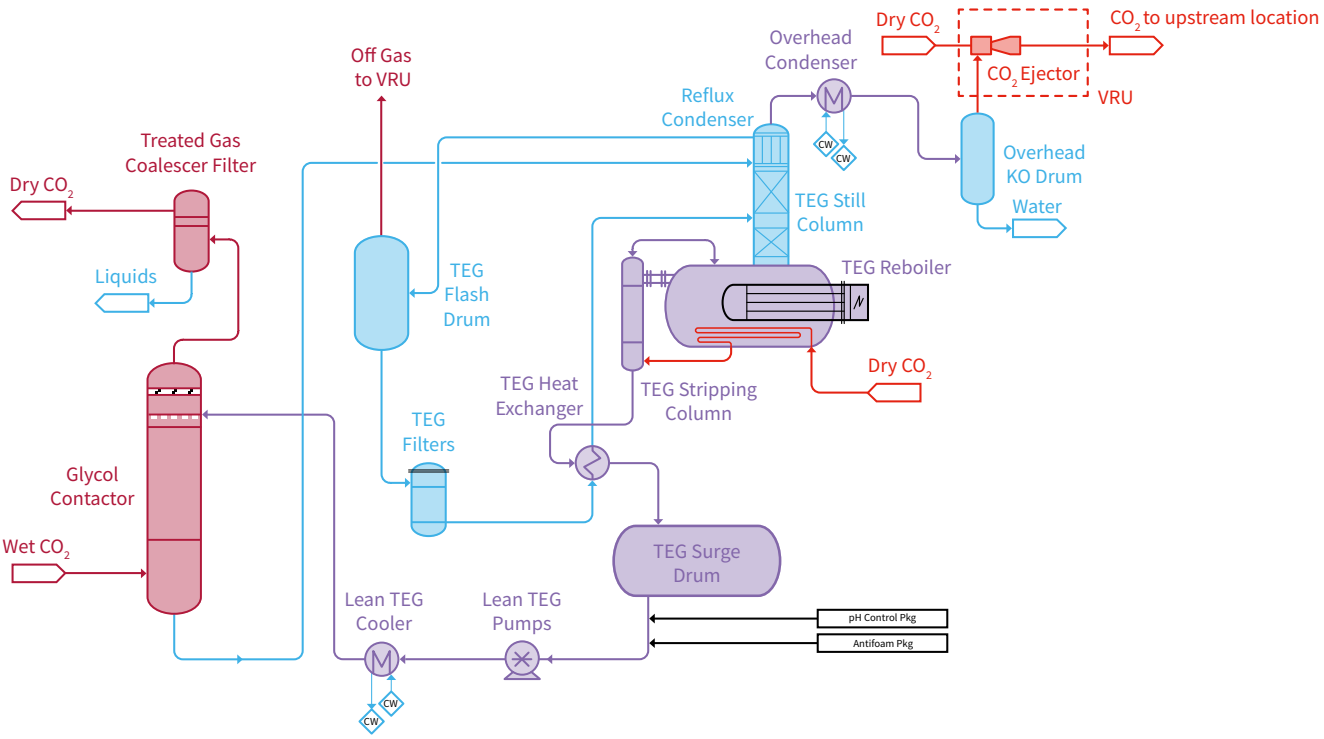
Molecular Sieve Dehydration

Molecular sieve temperature swing adsorption (TSA) technology employs zeolite microporus structures which 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 make this process a very appealing solution for certain applications. Molecular sieve technology has the capability of achieving very dry CO_2 gas which is beyond what is typically required for various means of CO_2 transport and is more expensive than the other technologies. Typically recommended for <1 ppmv water content specifications.

Glycol (TEG) Dehydration

Triethylene Glycol (TEG) is an absorption-based gas dehydration method that utilizes a liquid solvent to selectively absorb water from the CO_2 stream. It is known for its high dehydration efficiency and commercial viability. It results in a relatively higher water content level than the other dehydration technologies, but is known for its cost effectiveness. TEG dehydration systems are able to dehydrate gas streams typical down to 50 ppmv water content specifications.

Glycol Dehydration at a glance



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Our Glycol Dehydration solution offering:

- Meet the CO_2 dryness specifications of your project utilizing cost effective solution
- Stick-built and modularized option
- Compact TEG (Super Purifier)
- Provide you with the lowest OPEX solution for long term operation
- Flexible design for dehydration efficiency
- Incorporation of health, safety and environmental control

We offer efficient & optimized process design, all the way to fabrication and package delivery for CO_2 Dehydration systems. We are comfortable taking on full scope and split scope solutions to meet the project needs. We are comfortable working with EPC, project developer, and consortium arrangements to support a wide range of project requirements. We have direct relationships with key EPC companies, midstream/sequestration companies, and CCUS developers to offer a full turnkey solution together.

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:** 1-18m3/h (meter cube 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 to recover off gas CO_2 to eliminate emissions
- Qualified for onshore and offshore applications

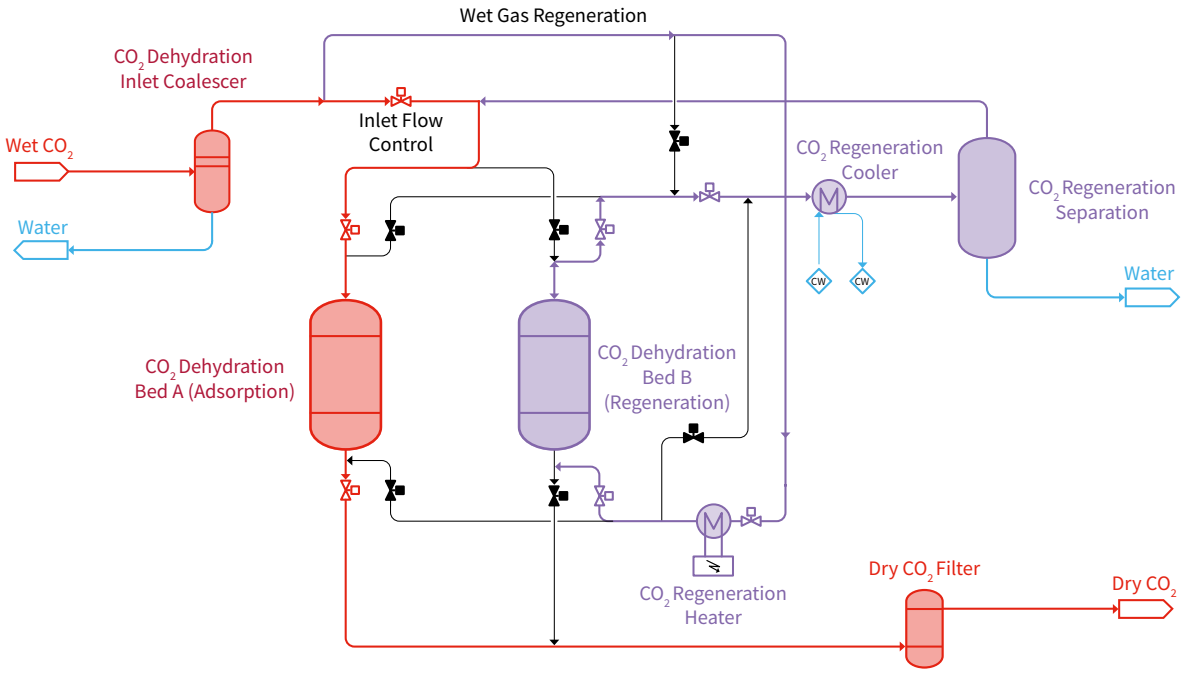
Standardize TEG offerings:

- **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, make this process a very appealing solution. 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:

- 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 need of your project
- Provide you with lowest OPEX solution for long term operation
    - Lower regeneration temperatures compared to molecular sieve
    - Longer bed life compared to molecular sieves
- Smart Bed™ digital solution
- Flexible design for dehydration efficiency, pressure drop and turn down ratios
- Incorporation of health, safety and environmental control

We offer efficient & optimized process design, all the way to fabrication and package delivery for CO_2 Dehydration systems. We are comfortable taking on full scope and split scope solutions to meet the project needs. We are comfortable working with EPC, project developer, and consortium arrangements to support a wide range of project requirements. We have direct relationships with key EPC companies, midstream/sequestration companies, and CCUS developers to offer a full turnkey solution together.

BASF Sorbead® offering

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

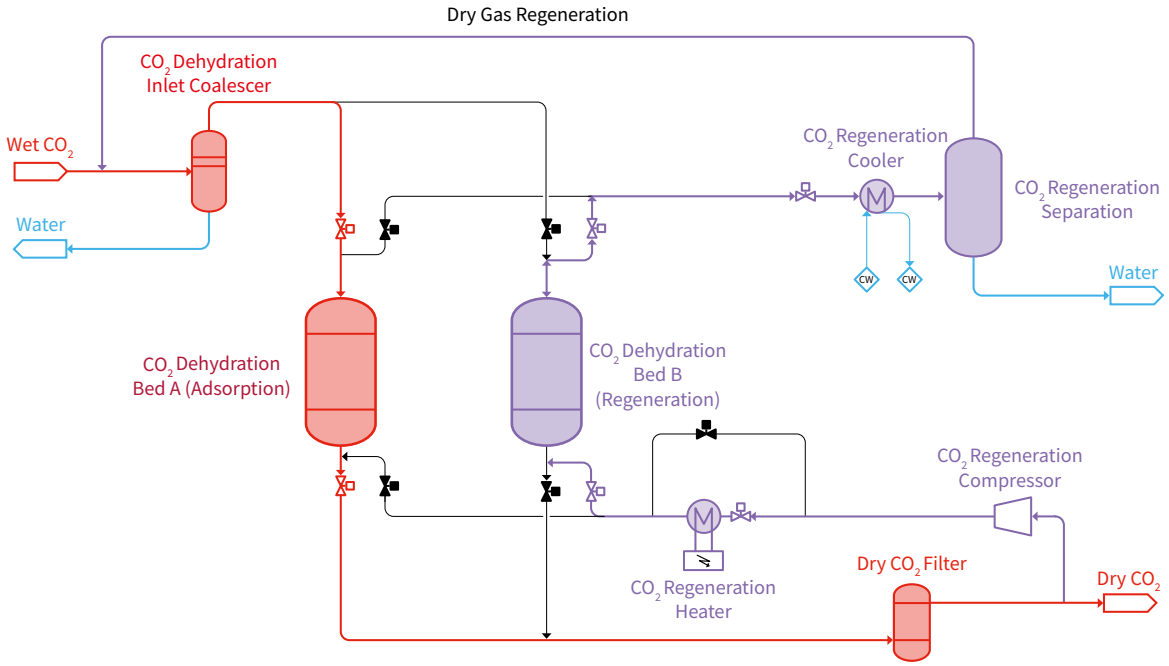
Notable features for TSA with BASF Sorbead®:

- 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 emission free
- Onshore and offshore designs

Molecular Sieve Dehydration

Molecular sieve temperature swing adsorption (TSA) technology employs zeolite microporus structures which 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 make this process a very appealing solution when low water specifications exist. Molecular sieve technology has the capability of achieving very dry CO_2 gas which is beyond what is typically required for various means of CO_2 transport as given above and is more expensive than the other technologies. Typically recommended for <1 ppmv water content specifications.

TSA with dry gas regeneration at a glance



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 regenergion or dry gas regeneration configuration to meet the need of your project
- Provide you with lowest dryness requirements
- Smart Bed™ digital solution
- Flexible design for dehydration efficiency
- Incorporation of health, safety and environmental control

We offer efficient & optimized process design, all the way to fabrication and package delivery for CO_2 Dehydration systems. We are comfortable taking on full scope and split scope solutions to meet the project needs. We are comfortable working with EPC, project developer, and consortium arrangements to support a wide range of project requirements. We have direct relationships with key EPC companies, midstream/sequestration companies, and CCUS developers to offer a full turnkey solution together.

Molecular Sieve offering

- **Typical CO_2 flow capacity:** ~10 to 5000 ktpa CO_2
- **CO_2 water inlet composition:** ~saturation
  - Flexible composition
- **Technology:** Temperature Swing Adsorption (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 case to case
- Acid resistant
- Fast start-up times
- Inherently emission free
- Onshore and offshore designs

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