DEHYDRATION OF CARBON DIOXIDE FOR CCUS

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Agenda

Dehydration of CO_2 is required to avoid corrosion failures of pipelines and blockages due to hydrates and ice.

We compare different dehydration methods and we present a method for setting the CO_2 dehydration specification.

1. Market for CO2 dehydration
2. Why dehydrate CO_2
3. CO_2 vs methane
4. Some common specifications
5. CO_2 phase envelope
6. Dehydration methods
7. Setting dehydration specification

Market for CO2 Dehydration

Australian locations requiring CO_2 dehydration

Global: [Facilities - Global CCS Institute (co2re.co]()

Market for CO_2 dehydration

- One existing project, several proposed locations and projects in Australia, as shown on the map.
- Globally, CO_2 handling is proposed to increase 100 times, from 40 mtpa in 2020 to 4000 mtpa in 2035 (International Energy Agency, 2021).
- CO_2 is currently mainly captured at a large scale in these industries: natural gas processing, ammonia, ethanol and hydrogen production.
- Additional future CO_2 capture markets are power generation, waste-to-energy, bio-energy and direct air capture.

Why Dehydrate CO2?

Why dehydrate CO_2

Problems are caused by liquid water, hydrates and ice.

Liquid water:

- Corrosion due to carbonic acid at rates as high as 1 mm per week, 100 times worse than for natural gas.
- Flow assurance: dropped out water accumulates and slugs, same as in natural gas.

Hydrates:

- Blockages, same as for natural gas.

Water ice:

- Blockages: water freezes at 0°C regardless of pressure, same as natural gas but Joule-Thomson cooling is more severe.
- All the water condensation lines below 0°C in phase diagrams are ice, not liquid water.

CO2 vs Methane

Item	CO2	Methane	Comments
Standard gravity vs. Air	1.5	0.6	CO2 heavier than air
Freezing point at 1 bara	-78°C	-182°C	CO2 forms "dry ice"
Water saturation at 100 bara and 20°C, mg/Sm3	2,500	300	CO2 holds much more water
Auto-refrigeration (Joule-Thomson) upon depressuring from 100 bara and 20°C to 1bara	-87°C	-28°C	CO2 much colder
Pipeline design	Less understood	Standard	Fracture propagation different
Corrosivity in wet environments	Very high	Nil (if pure)	CO2 must not get wet
Hydrate formation at 150 bara	12°C	15°C	Depends on pressure and impurities

Some Common Specifications

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Project	Comments	Spec, ppmv (preferred)	Spec, mg/Sm3	Spec, lb/MMscf	Spec, ppmwt	Link
Snøhvit, Norway	Arctic	50	38	2.4	20	IPC2010 31564
Weyburn, Canada	1 mol% H_2S	315	240	15	130	project
Quest, Canada (winter spec.)		84	63	4.0	34	source
Bravo, USA		532	400	25	218	IPC2010 31564
Central Basin, USA	Low H_2S/O_2	630	480	30	261	IPC2010 31564
Cortez, USA	Low H_2S/O_2	630	480	30	261	IPC2010 31564
Sheep Mountain, USA	Low H_2S/O_2	630	480	30	261	IPC2010 31564
ISO 27913:2016		20-630				
Natural Gas Pipelines		64-148	48-111	3-7		

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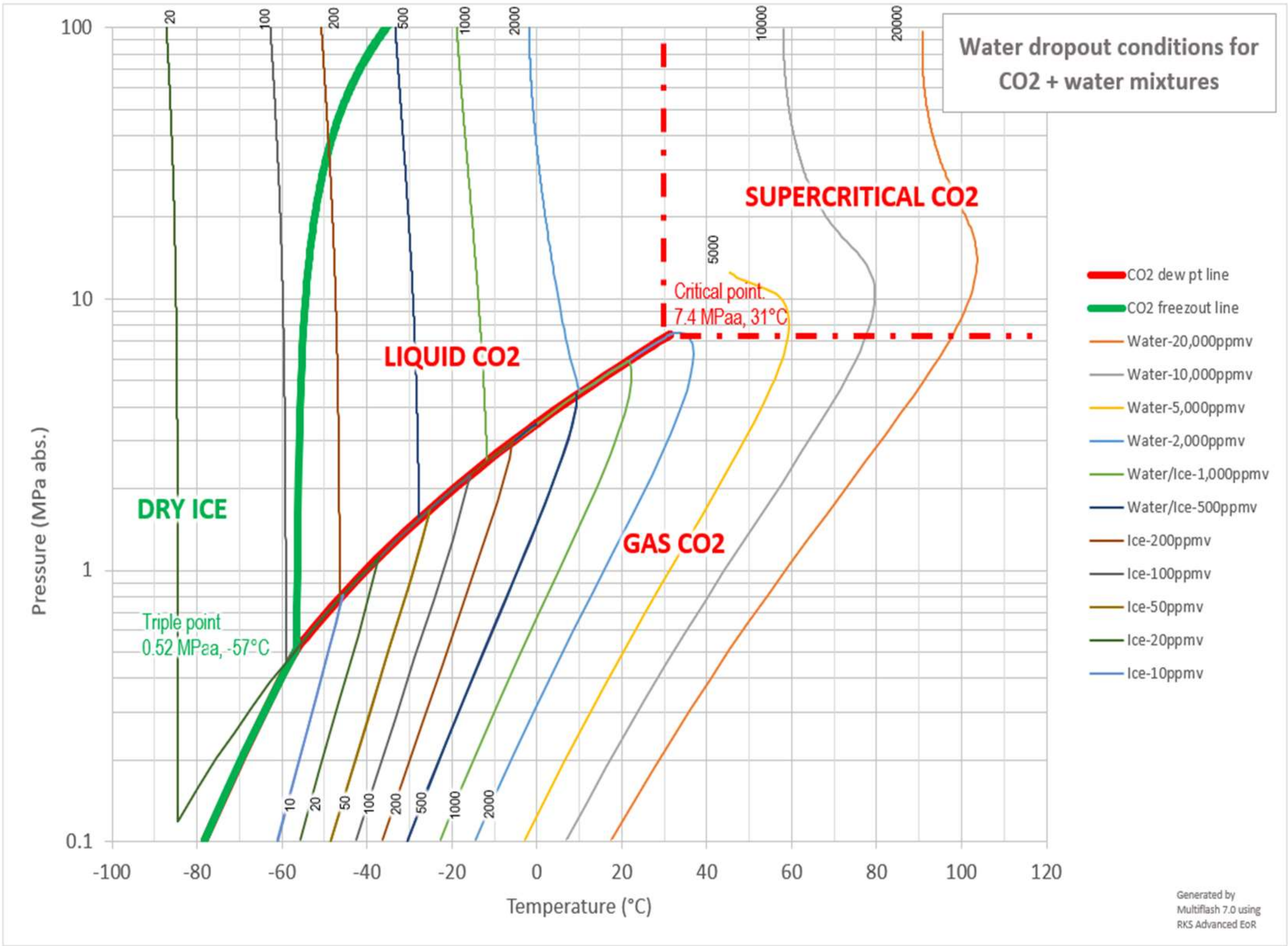
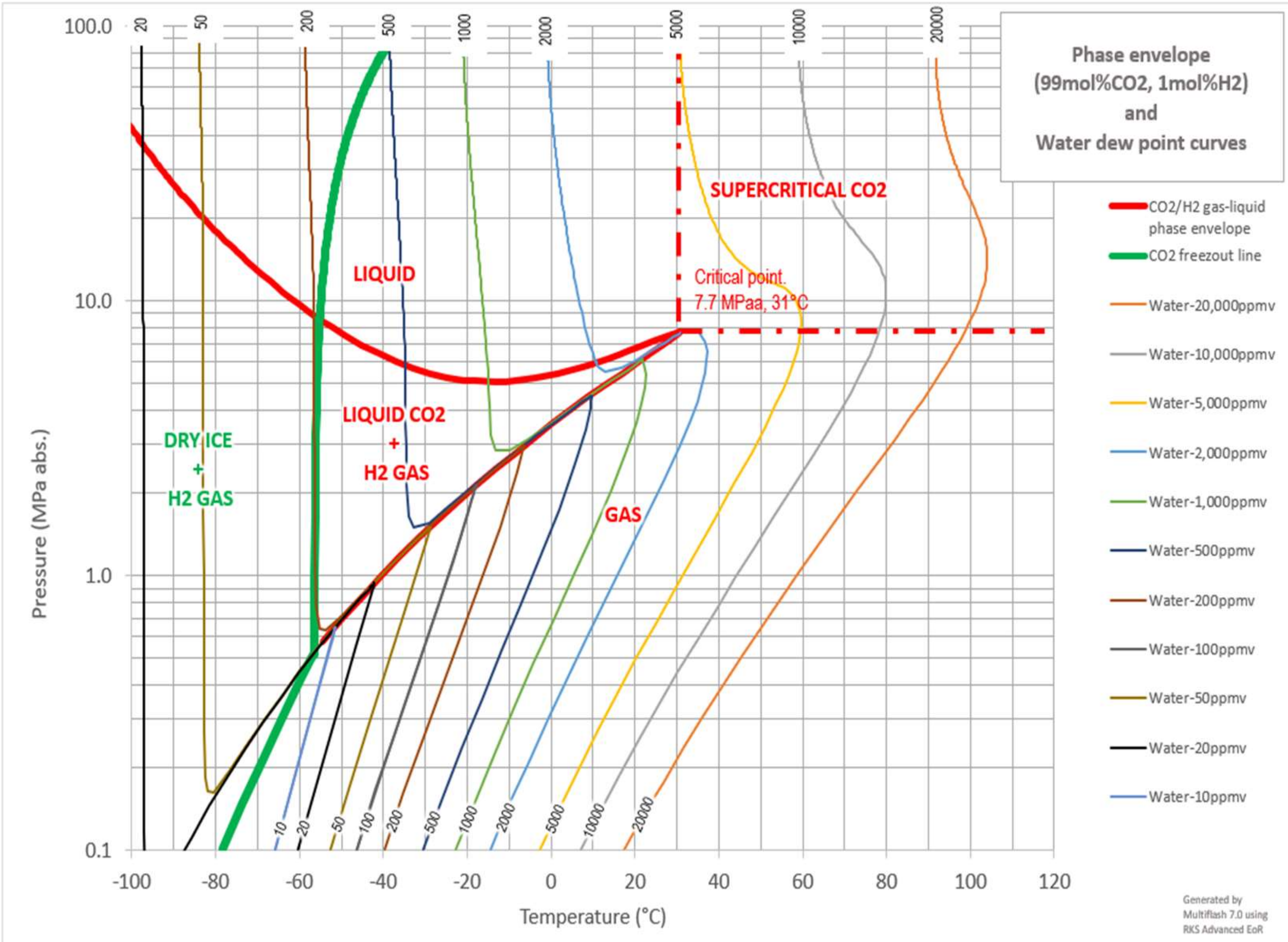
Phase Envelope Showing Water Dropout

100% CO2



Phase Envelope Showing Water Dropout

99% CO2 1% H2



Dehydration Methods

Solid adsorbents

- Porous solids which adsorb water on their surface.
- Three different types are activated alumina (AA), silica gel (SG) and molecular sieves (MS).
- Hydrogen sulphide (H_2S) tends to be adsorbed on the MS which is undesirable, but not on AA and SG.
- Methanol tends to be adsorbed onto SG, which is an advantage for recovery (financial).
- Liquid hydrocarbons, free water and amines can impact on some of the 3 types.
- All can achieve very low specs for water (1 ppmv for MS, 10 ppmv for AA and SG).

Triethylene Glycol (TEG) dehydration

- Water-absorbing/desorbing liquid. This is the most common method for CO_2 dehydration.
- Sizing needs to consider winter and summer feed rates and water loads, impurities, requirement for methanol recovery, optimal TEG flow, optimum regenerator reboiler temperature.
- Dehydration achievable to approx. 40 ppmv, limited by stripping gas rate (soft limit)

Joule-Thomson dehydration

- Simple, cheap, effective, and very small.
- Relies on auto-refrigeration due to pressure drop in a partial recycle stream within a compression train.
- Dehydration achievable to 400-600 ppmv, limited by hydrate formation temperature.
- A commercial mixer/blender is available.

Dehydration Methods

Evaluation Criterion	TEG	Solid Adsorption	Compression Recycling
Dehydration achievable	200 ppmv (no stripping gas) 40 ppmv (with stripping gas)	1-10 ppmv	400-600 ppmv
Technology maturity	> 20 years (for CO_2) many applications / common	Since 1984 (for CO_2), several applications	Since 2011, several applications
Retrofit	Difficult (space)	Difficult (space)	Easy
CAPEX	Medium	High	Low
Proprietary technology	No	Yes	Yes (mixer)
Methanol recovery	Yes	Yes (for silica gel only)	Yes
OPEX	Medium	Medium	Low

Setting Dehydration Specification

Follow our nine steps to set the dehydration specification

1. **Phase envelopes** should be generated for water saturation and hydrate formation, considering the full range of all possible contaminants.
2. **Means of CO_2 transportation** and its location need to be considered: trucking, shipping, onshore pipelines, subsea pipelines, urban vs. remote locations.
3. **Materials of construction (MoC):** is using corrosion resistant alloys an option, such as in very short pipelines? This may eliminate the need for dehydration, e.g. Sleipner platform.
4. **Ambient conditions:** consider minimum ambient temperatures for sea, soil and air. They can impact on both MoC and dehydration spec.
5. **Transient conditions:** consider commissioning depressuring and re-pressurisation requirements. These will generate the lowest temperatures and can impact on both MoC and dehydration spec.
6. **Dehydration technologies:** consider different technologies using the evaluation criteria in the comparison table and their applicability.
7. **Simulate the compression plant** to establish all pressures and temperatures along the compression path and decide where to place the dehydration unit.
8. **Plot compression and dehydration** on the phase envelope from step 1, checking for pressure and temperature margins vs. water and hydrate formation downstream of dehydration.
9. **Selection:** the design team should select the dehydration specification and method considering all of the above.

TEG dehy

- 2 x 34 MMcfd
- InSalah Algeri
- 200 ppmv H2
- supplied by A

Thank you!