Why Not Let Nature Do the CO_2 Dehydration? Risks and Rewards of Ambient Water

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CO_2 and Water Mix

- That's the problem
- When it comes to reinjected gas:
  - Hydrates can form
  - With liquid water carbonic acid forms which corrodes carbon steel especially at high CO2 partial pressures
- What to do about it?

Other Choices than Dehydration

- Make the system corrosion resistant by use of materials other than carbon steel
  - Treatment for corrosion
  - Hydrates are still a problem
    - Formation temperature ~52 deg F for dense phase
- Chemicals
  - Could mitigate corrosion and hydrates but…
  - Nearly impossible to apply due to low lubricity

Dehydration

- Well known technologies are available to achieve dehydration
- All technologies work and widely used in natural gas and dense phase CO_2 service
- Principle means of mitigating both corrosion and hydrates

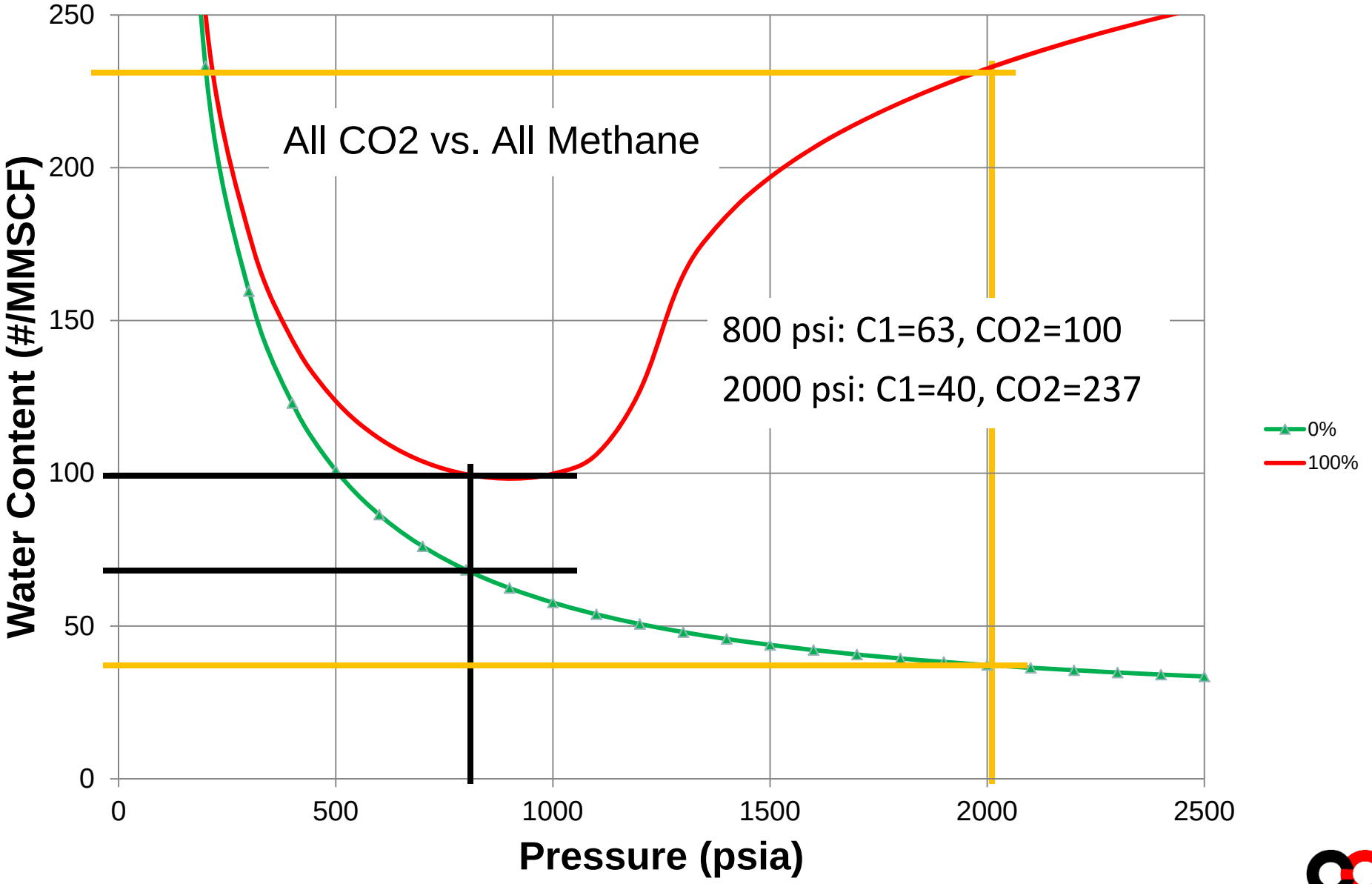
How Much Dehydration

- The dehydration required is dictated by the process intent
- If reinjection is needed considerable water may be left, often about 35#/MMSCF in commercial pipelines
- If processing to recover hydrocarbons is desired far more dehydration is required

How to Dehydrate

- Types of dehydration:
  - Absorption: TEG, DEG, MEG, Glycerol
  - Adsorption: Mole Sieve and Silica Gel
  - Membranes: Forget about it. Must dehy first!
- Separation dehydration: Niche process that only works for acid gases (CO_2 & H_2S)
- Rest of presentation explores this option for CO_2 in dense phase

CO2 - Methane Water Content vs. Pressure @ 100 deg F



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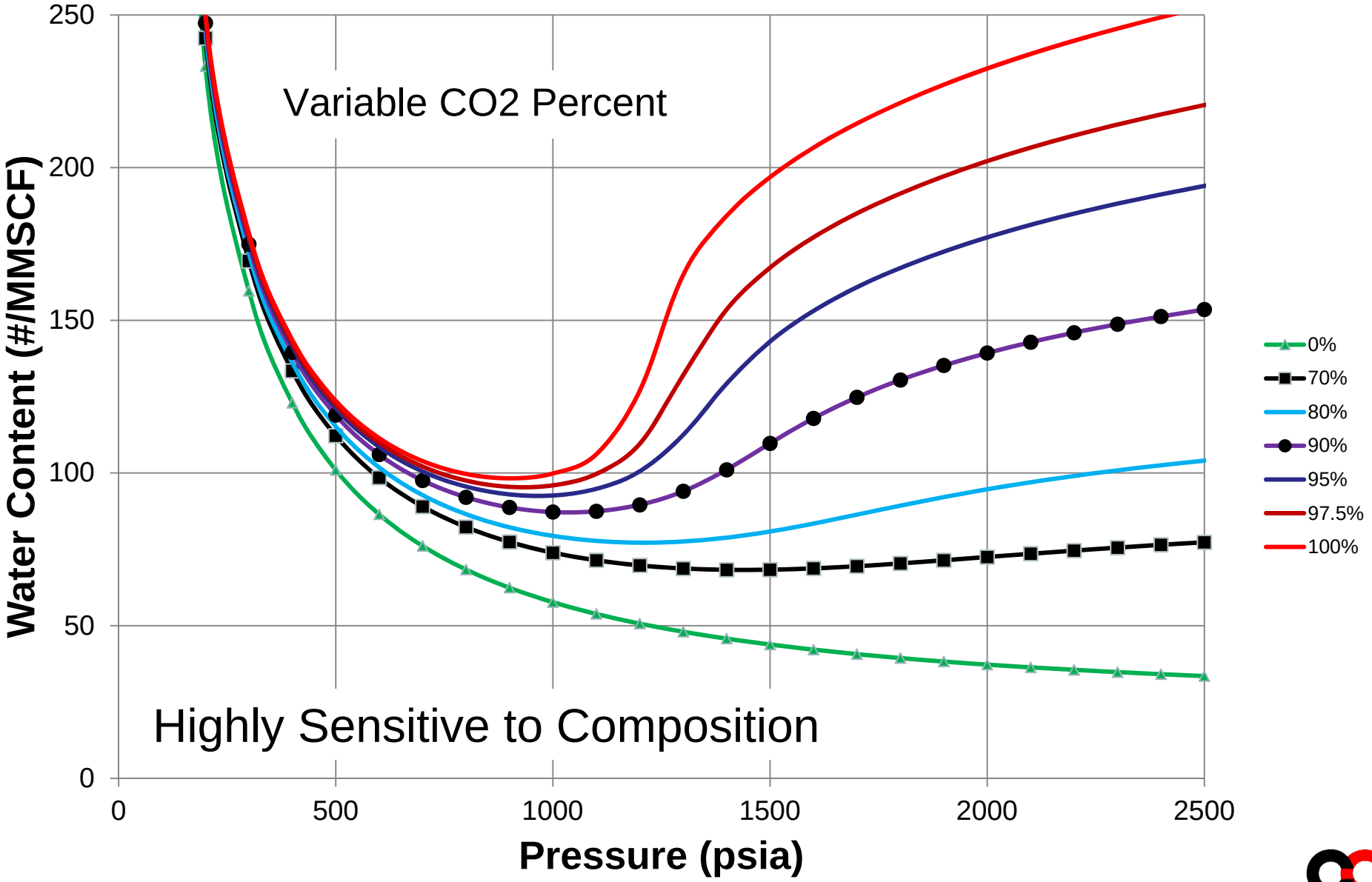
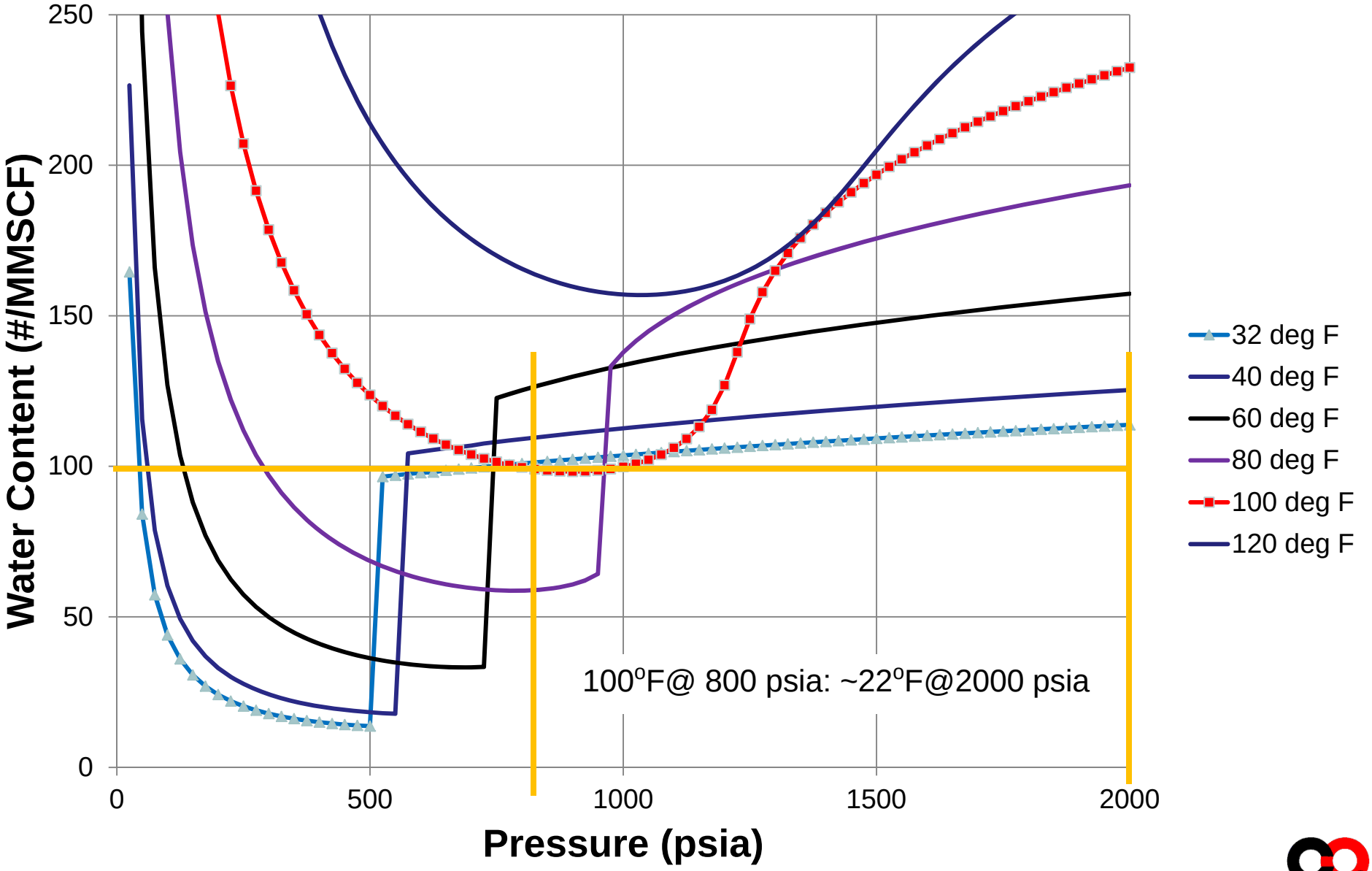


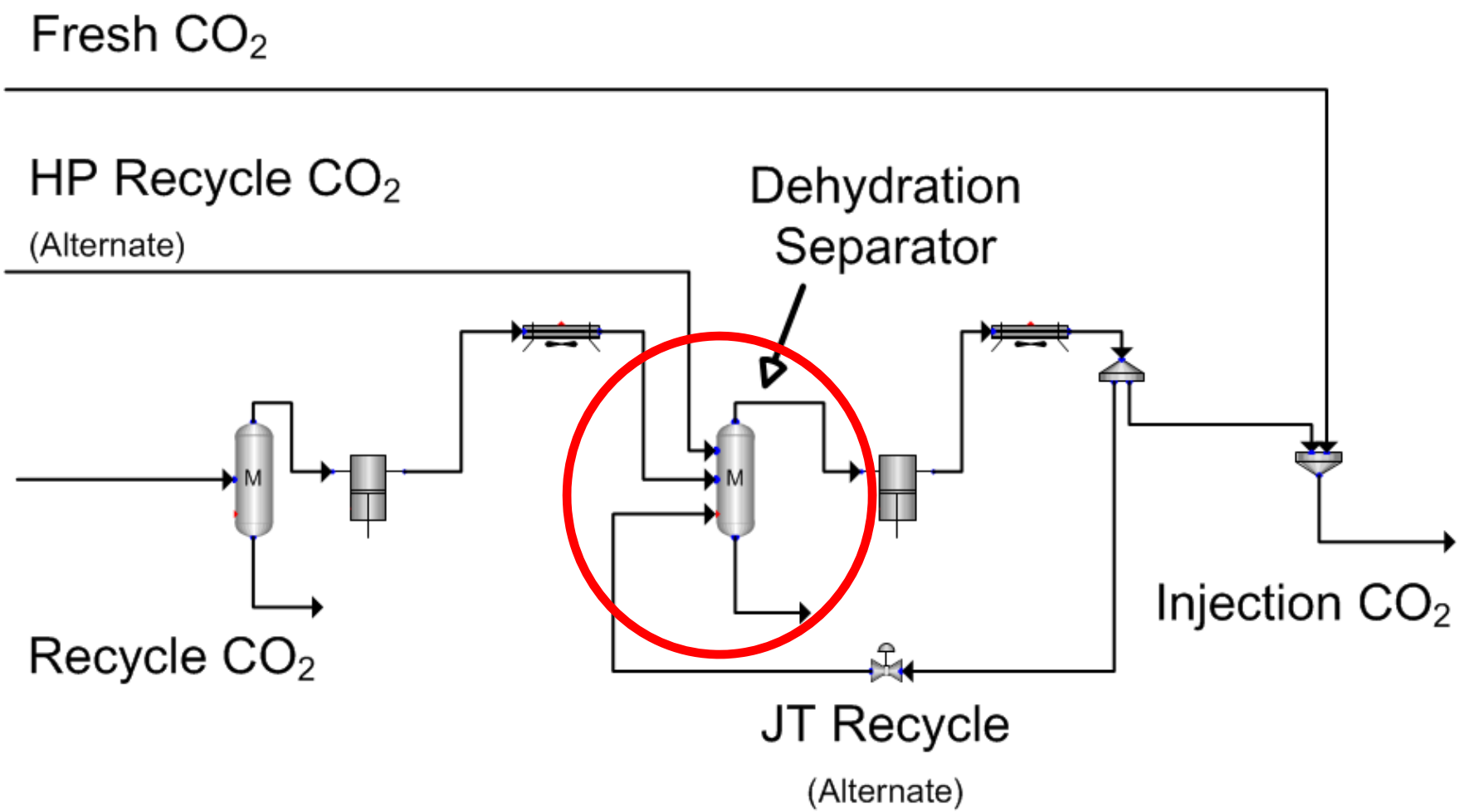
Water Content in CO_2 vs. Pressure @Various Temperatures



Properties Recap

- CO_2 has a minimum water saturation pressure that is the target of separation dehydration
- Highly sensitive to composition
- Highly sensitive to temperature
- Must avoid liquefying CO_2 at the dehydration separator

Mechanical Configurations



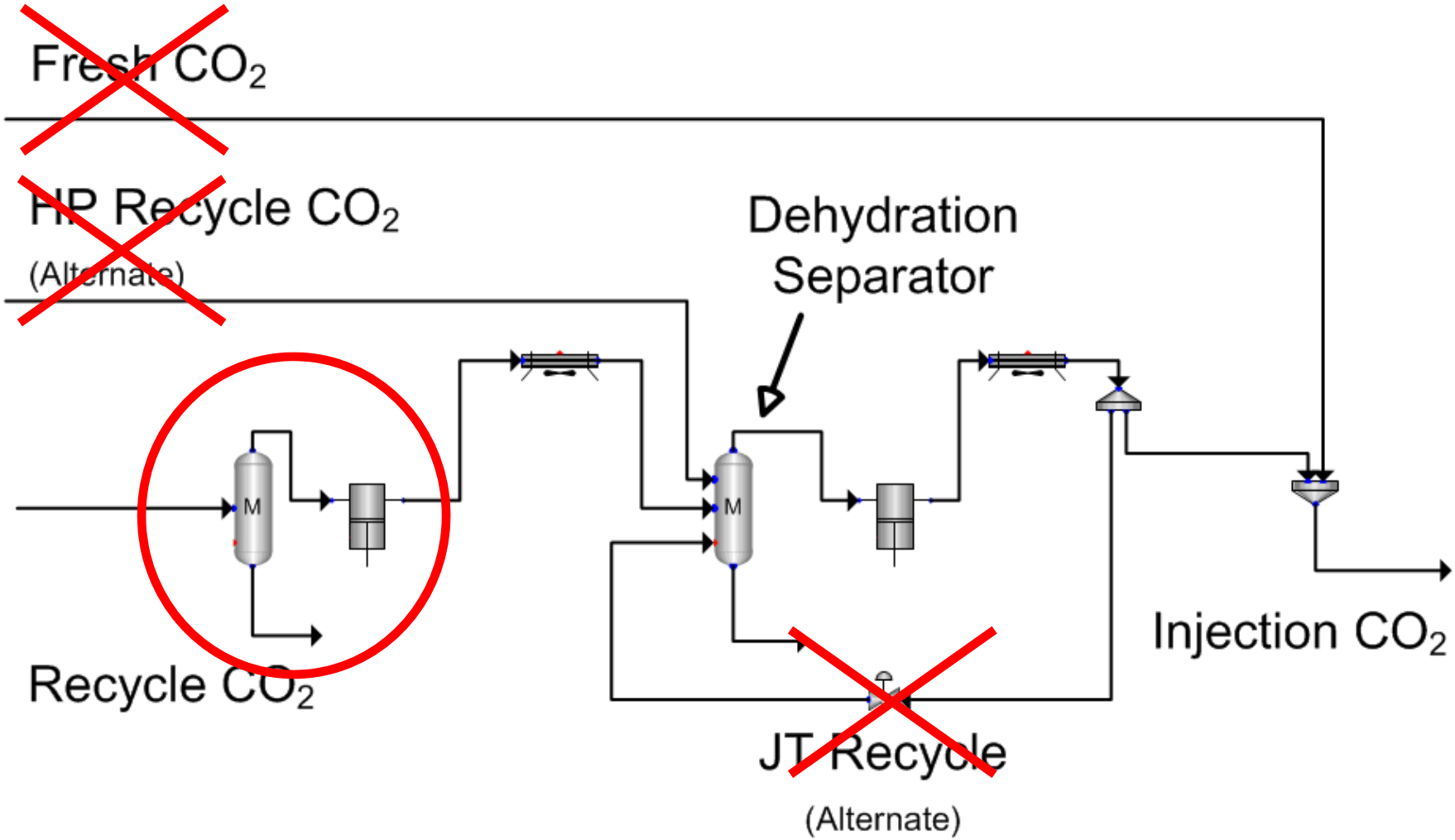
Dehydration Separator Temperatures

- Dehydration separator: three temperature scenarios:
  - Compressor cooler discharge temperature (most common)
  - Field gathered gas temperature
  - Refrigeration via JT Recycle

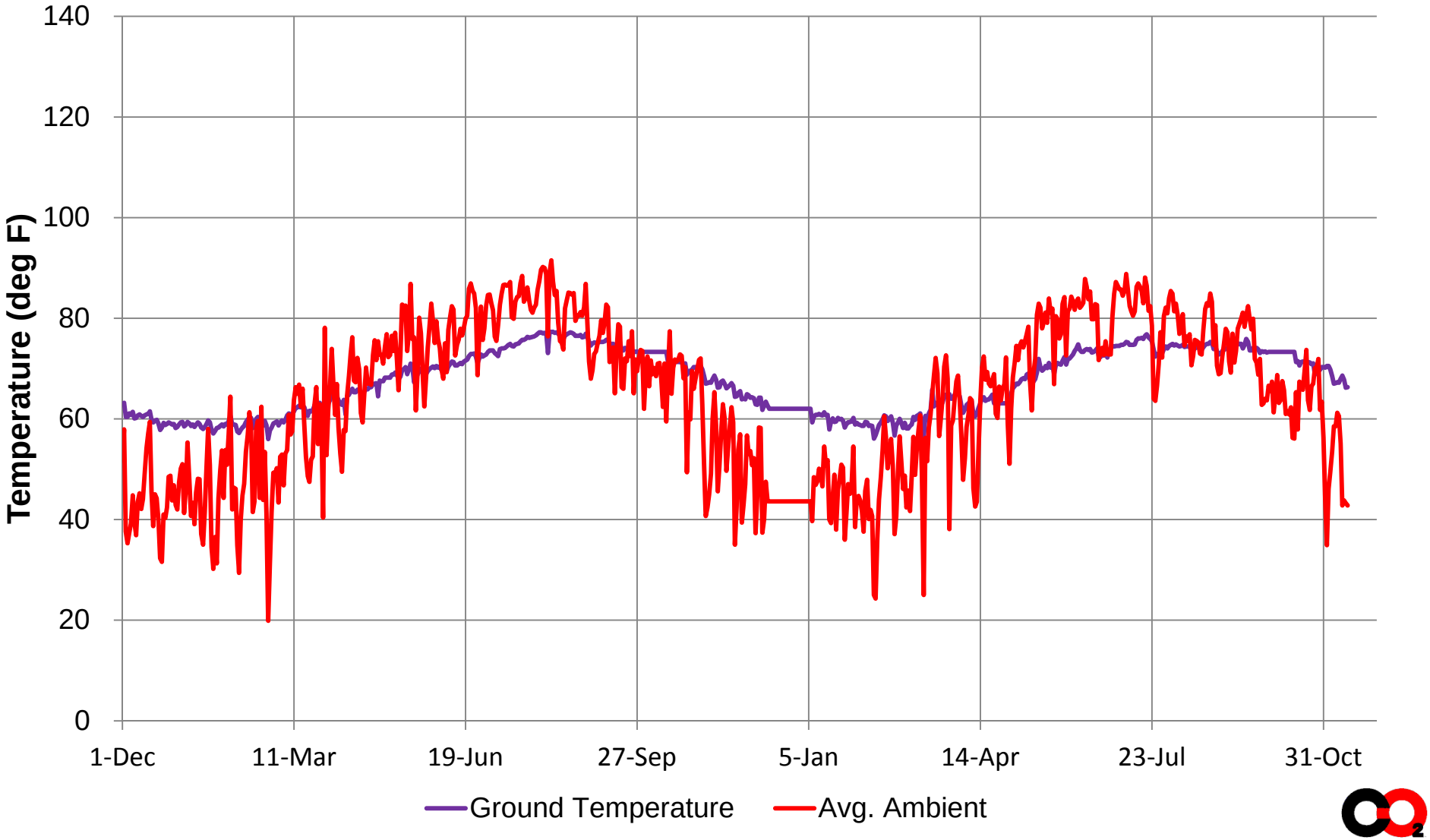
Applying Learnings

- Consider the case of gas from a compressor discharge air cooled heat exchanger being reinjected.
- When is separation dehydration sufficient for reinjection of produced gas?
- Actual ground temperatures and average ambient temperatures
- Assume average temperature plus 40^{o}F is the maximum temperature
- Assume pure CO_2
- Assume separation pressure is 700 psia
- Assume injection pressure of 1600 psia

Mechanical Configurations



Ground, Average Ambient Air, and Assumed Cooler Temperatures vs. Time



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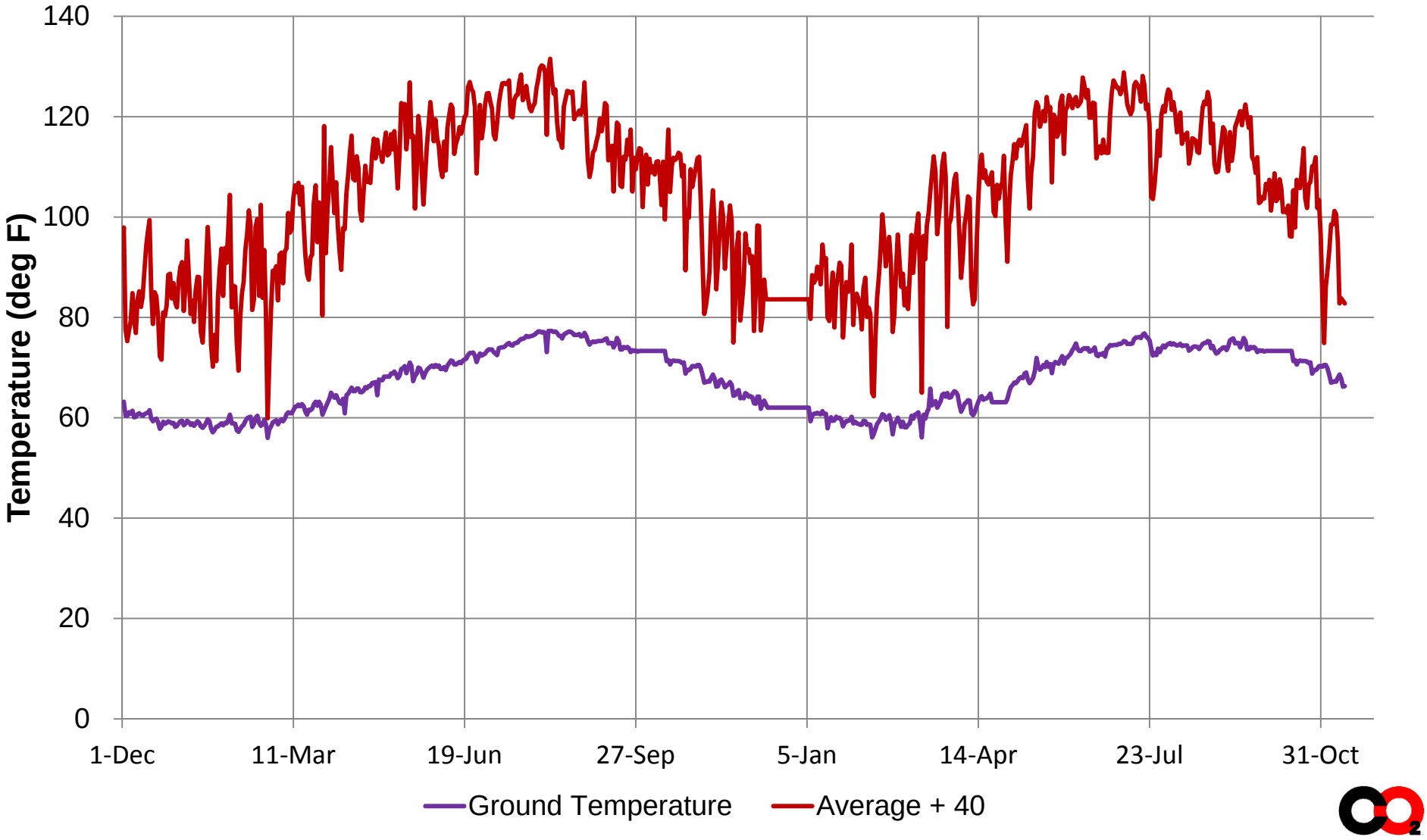
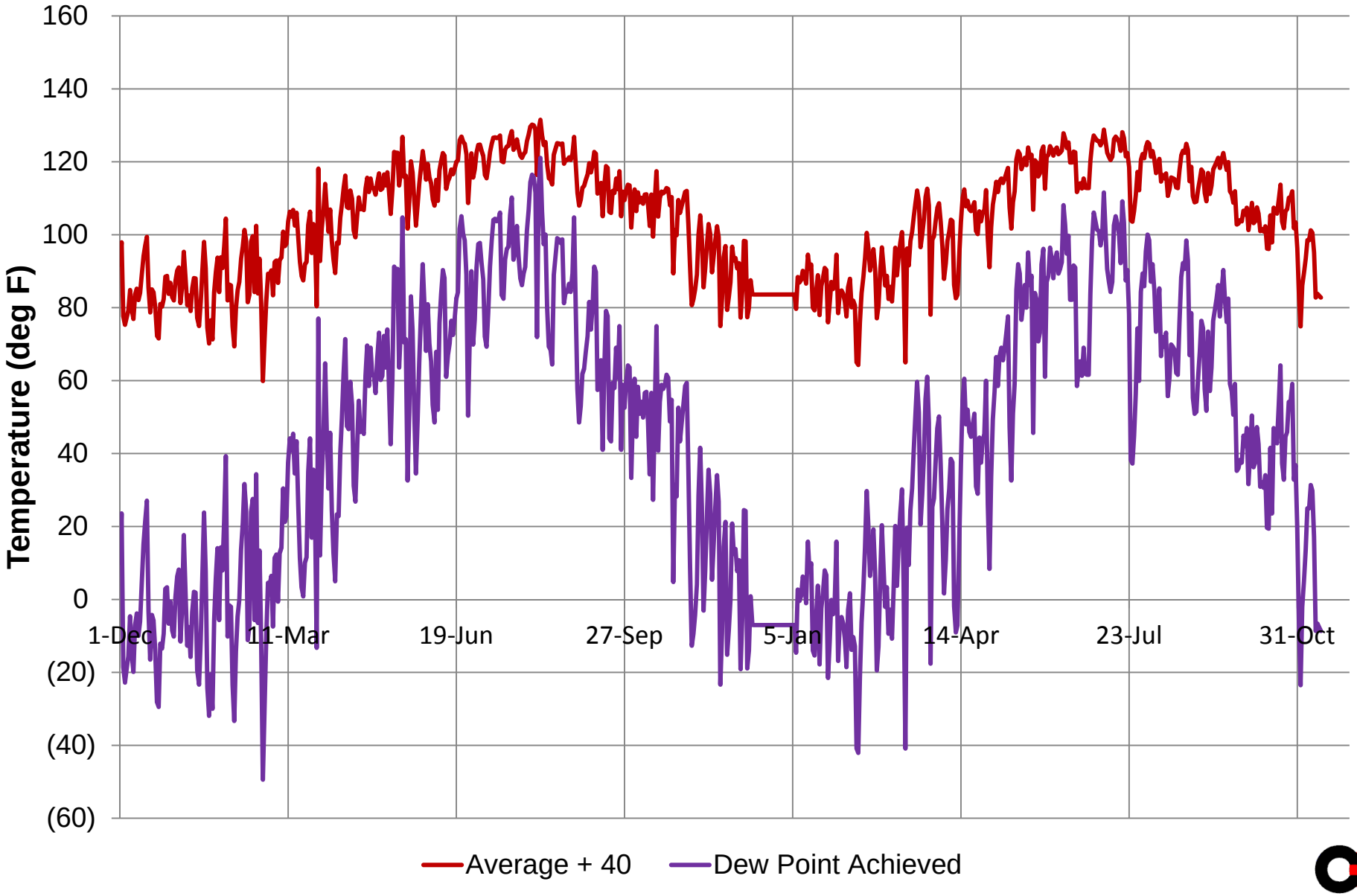
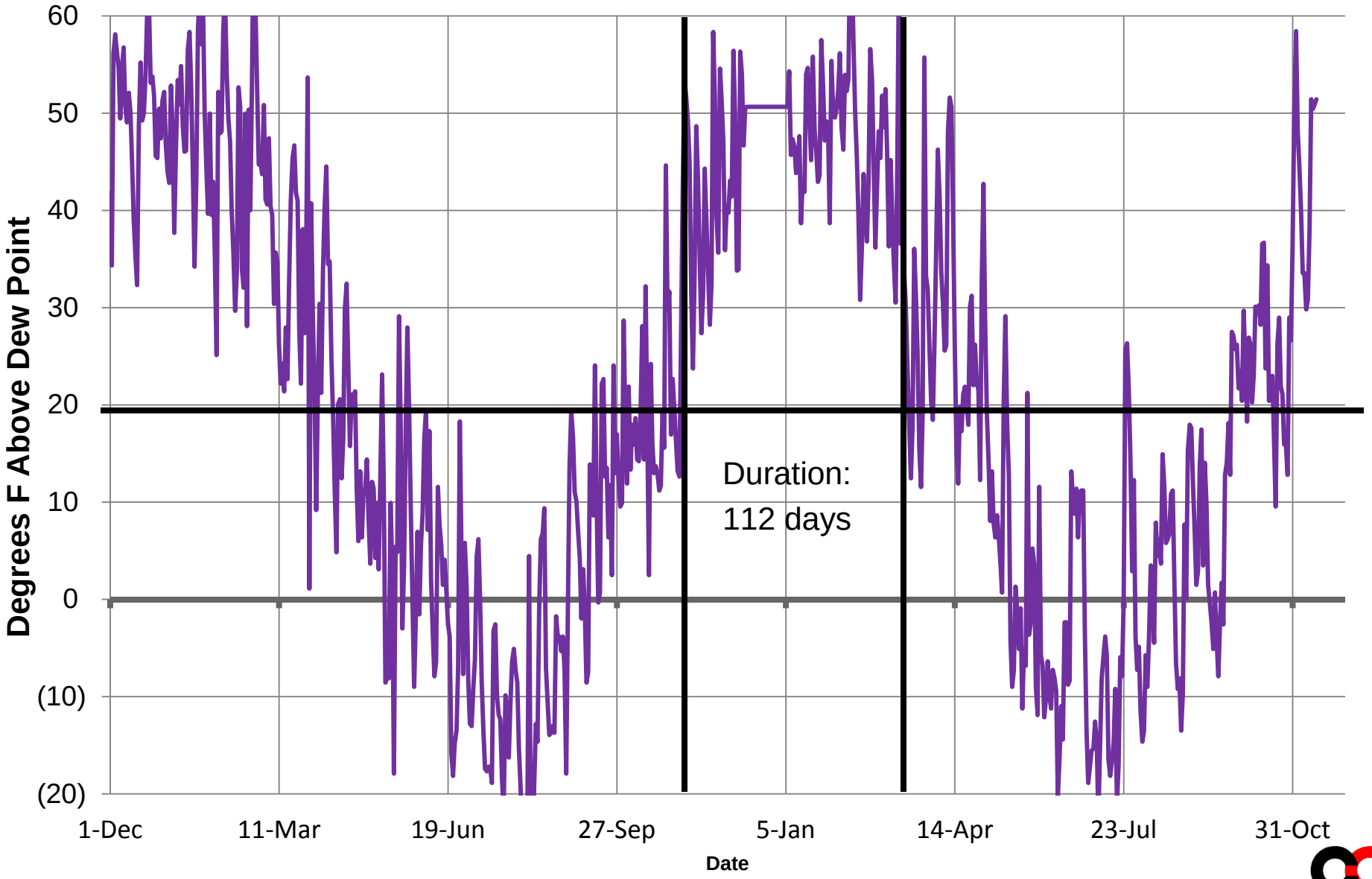


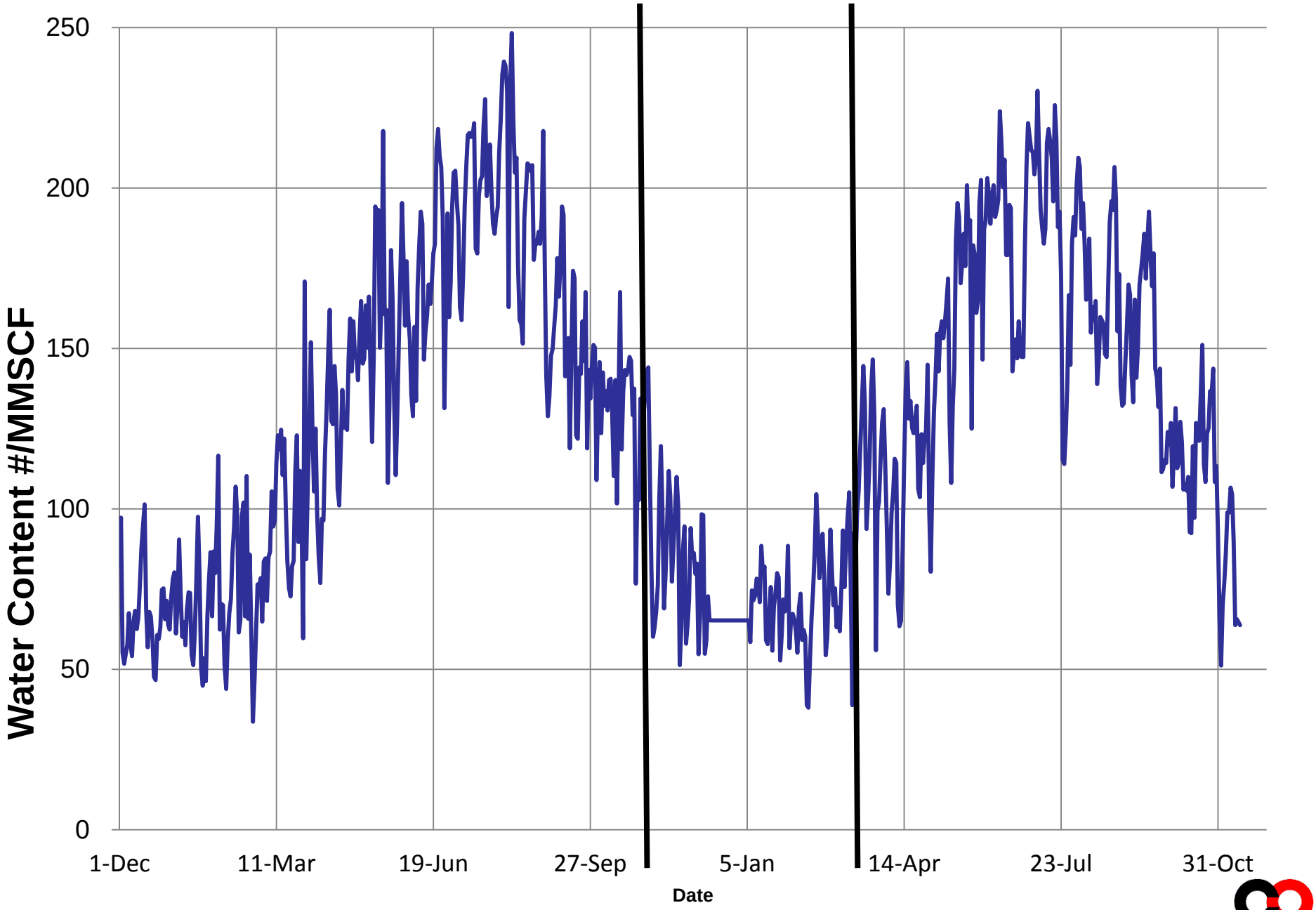
Assumed Cooler Temperatures and Dew Point Achieved vs. Time



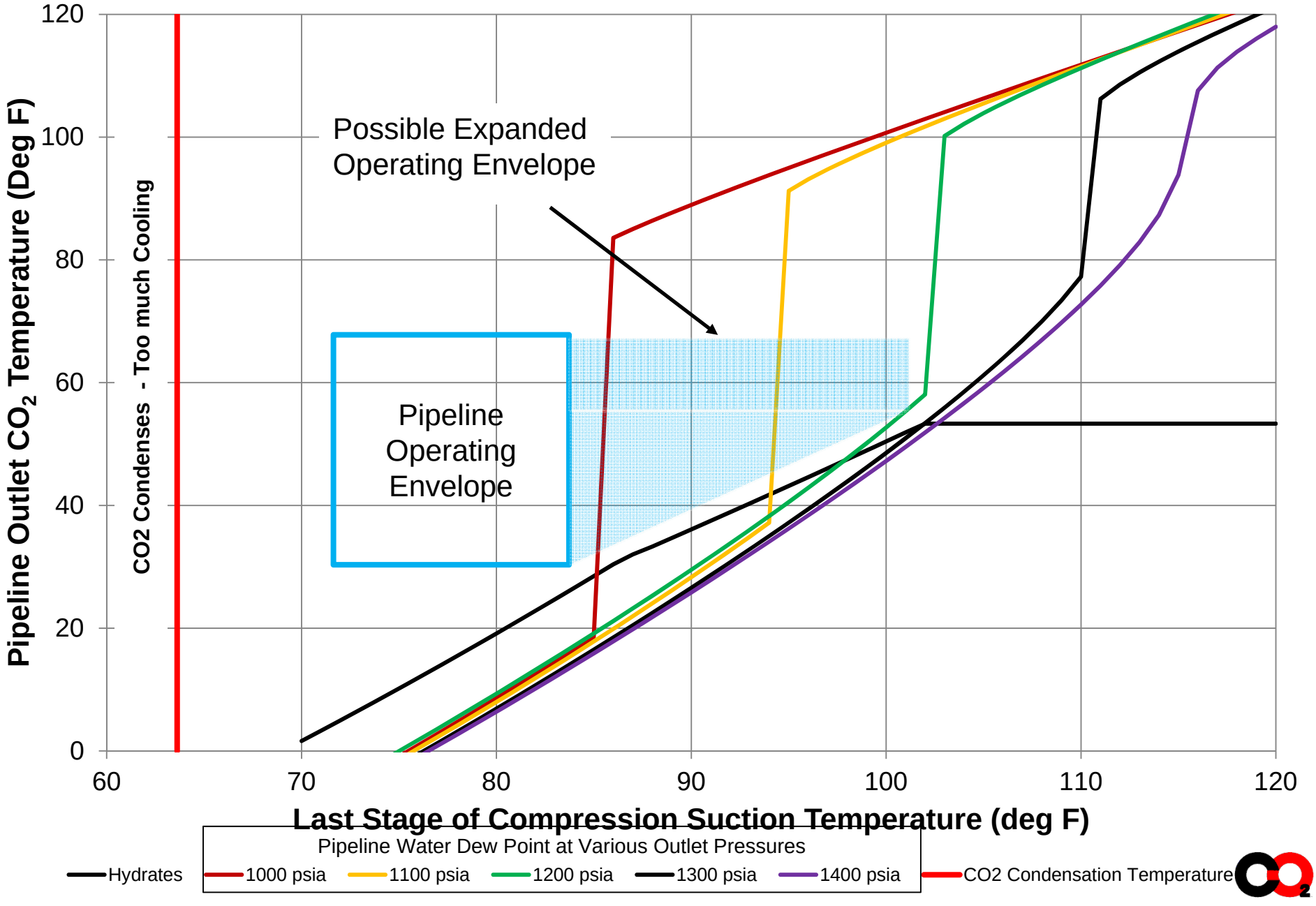
Dew Point Approach Temperature vs. Date



Water Content vs. Date



No-Dehy: Pipeline Hydrate and Dew Point Temperatures vs. CO2 Compressor Suction Temperature @ Last Stage of Compression



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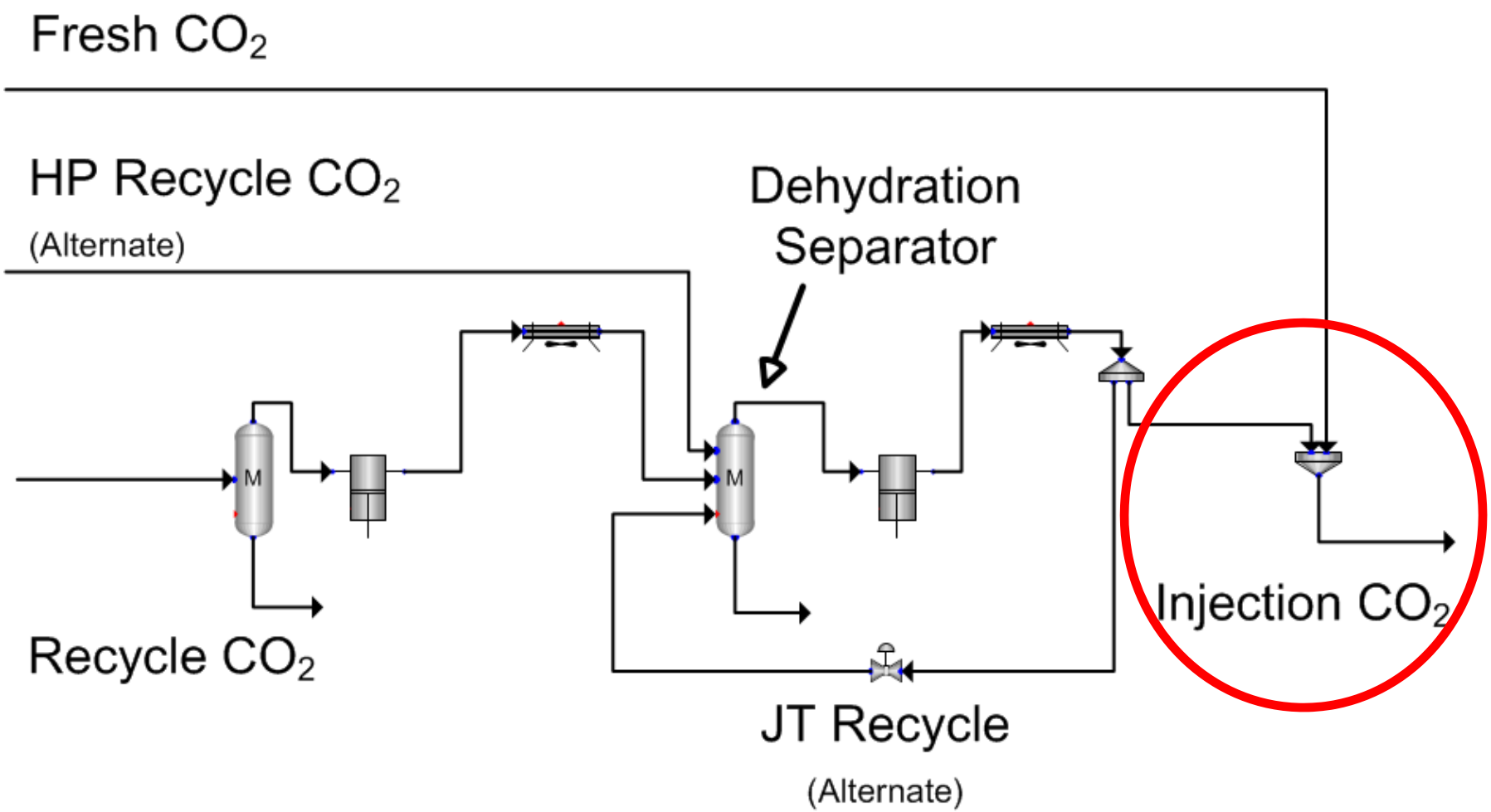

Pulling a Rabbit out of the Hat

- Fresh CO2 is the rabbit in-the-hat
- It can be mixed reduce the water content and increase ability to keep it dry
- The way to consider the mixing is to:
  - Calculate the mixed water content
  - Calculate the revised composition
  - Run a simulator to calculate the dew point

Avoiding Separation Anxiety

- Ambient temperature separation dehydration is often feasible but usually not year round
- Must understand changing conditions:
  - Composition
  - Separation temperature and pressure
  - Worst case pipeline temperature and pressure
- Proper process simulations required

Controlling Temperatures

- Passive – for injection pipeline:
  - Depth of pipe burial
  - Insulation
- Active - Controlling the temperature of separation
  - Easy in the North Sea
  - Refrigeration – Usually available only at processing facilities
  - Dexpro™ – JT control of temperature

Thank You!

Questions?

Appendix

- Process calculations made utilizing: "VMG Sim v9.0 (Build 62) April 2015" Thermo = "APR for Natural Gas 2" by P.A. Carmody

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