

PS CO₂ Worst-Case Discharge Scenario – Well Survivability of Existing Casing Systems under CO₂ Discharge Conditions

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Abstract

The concept of a Worst-Case Discharge (WCD) is well established in the oil and gas industry as the engineering and regulatory basis for design and response planning. A comparable definition for CO₂ storage wells has not yet been established, despite the potential severity of an uncontrolled release during drilling, injection, or containment loss. Unlike hydrocarbons, CO₂ is heavier than air, and its rapid expansion at atmospheric pressure can cause intense local cooling, icing, and asphyxiation hazards. The study examines the well response to a hypothetical uncontrolled discharge using a nodal analysis framework to capture the coupled pressure and temperature behaviour along the wellbore. The analysis focuses on the drastic and rapid depressurisation associated with an Absolute Open Flow (AOF) event, which represents the upper limit of WCD conditions. This allows capturing the extreme frictional and accelerational pressure losses that develop as the well discharges freely to atmosphere. The model applies boundary conditions representing the reservoir injectivity and discharge potential at depth, and atmospheric pressure at the surface release point, as would occur for a platform well. The transient loads acting on the tubulars during rapid CO₂ depressurisation are evaluated to determine whether the existing casing system can maintain integrity long enough for control to be regained. The combined effects of Joule–Thomson cooling, cold-induced tensile stress on tubulars, cooling of annular fluids with consequent reverse annular pressure build-up, and cement deterioration are considered to assess the survivability of the current well architecture. The outcome provides a technical basis to evaluate the endurance of existing wells under accidental CO₂ release, define integrity limits, and identify where mitigation or strengthening may be required to ensure containment until the well can be safely shut in.

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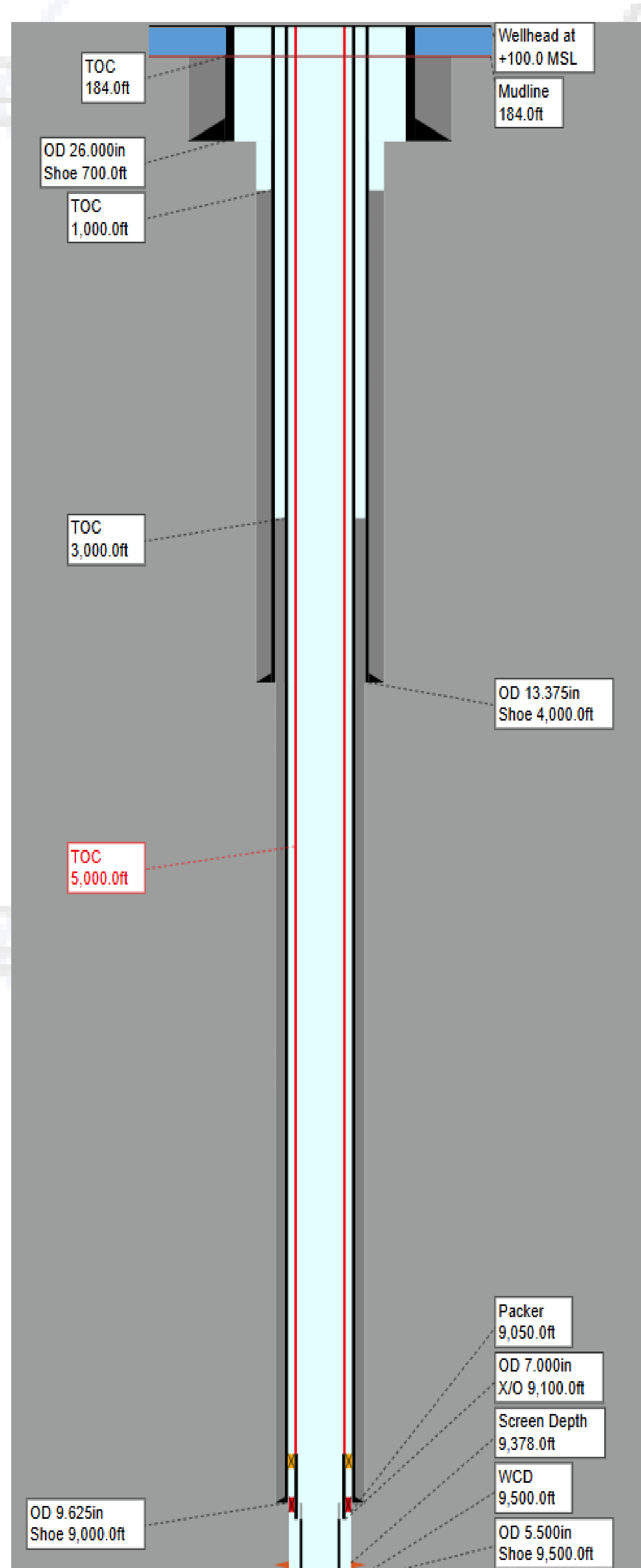
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1 PROBLEM STATEMENT:

- Newly drilled platform infill well
- Drilling into CO₂ recharged reservoir
- Well control event in 8 1/2" section after installation of 7" tieback string
 - Resulting in uncontrolled release of CO₂ at atmospheric pressure
 - Worst-Case Discharge (WCD) equivalent modelling scenario
- Determine survivability of well tubulars exposed to uncontrolled CO₂ flow
 - Pressure and temperature effects on tubular strings and annuli

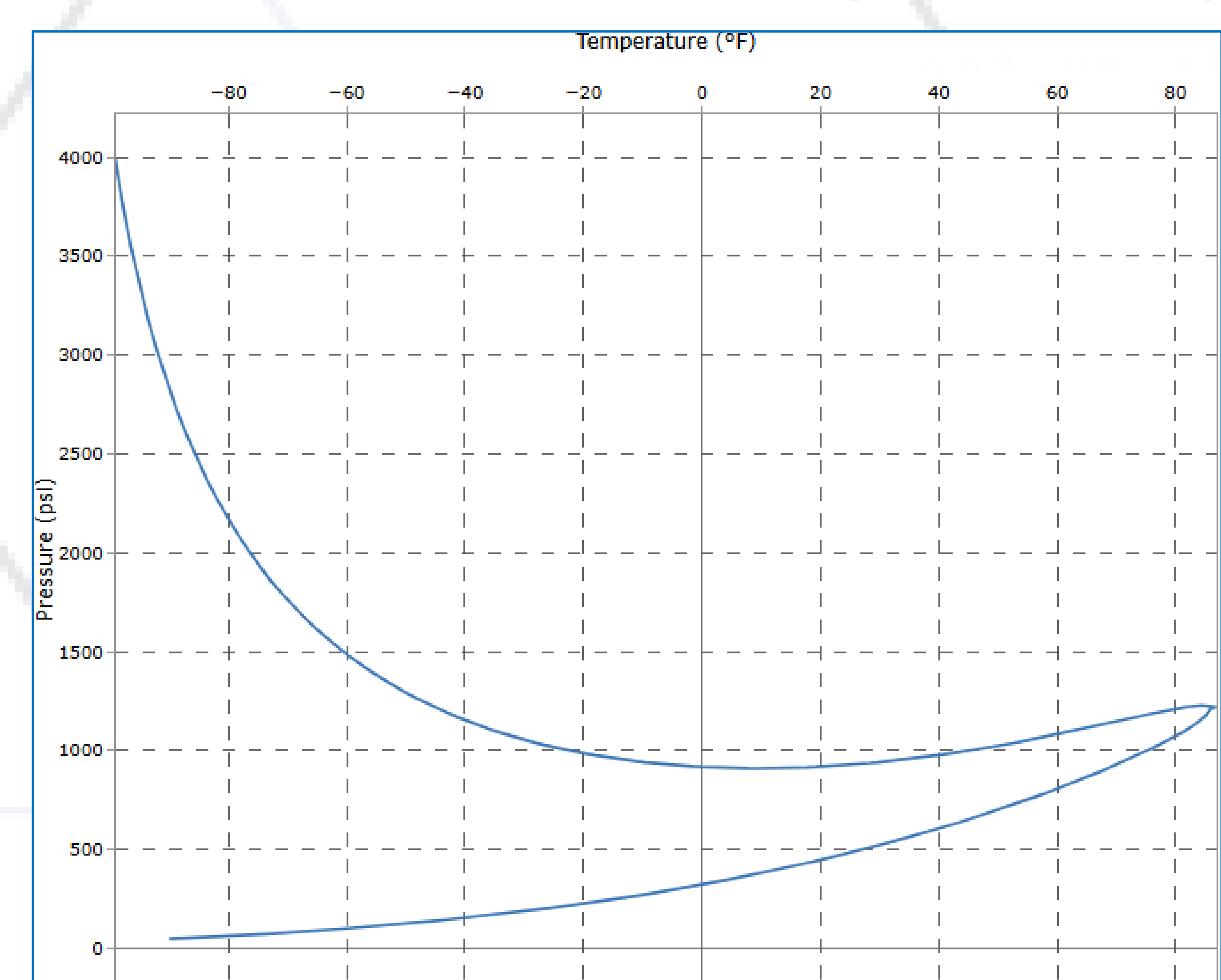
2 WELL ARCHITECTURE:



Strings	Type	Hanger (ft MD)	Shoe (ft MD)	Hole Size (in)	TOC (ft MD)	Fluid
26"	Casing	0.0	700.0	36.00	184.0	Seawater
13.375"	Casing	0.0	4,000.0	17.50	1,000.0	11.0ppg WBM
9.625"	Casing	0.0	9,000.0	12.25	3,000.0	11.0ppg OBM
7"	Liner	8,700.0	9,500.0	8.50	8,700.0	12.5ppg OBM
7"	Tieba...	0.0	8,700.0		5,000.0	12.5ppg OBM

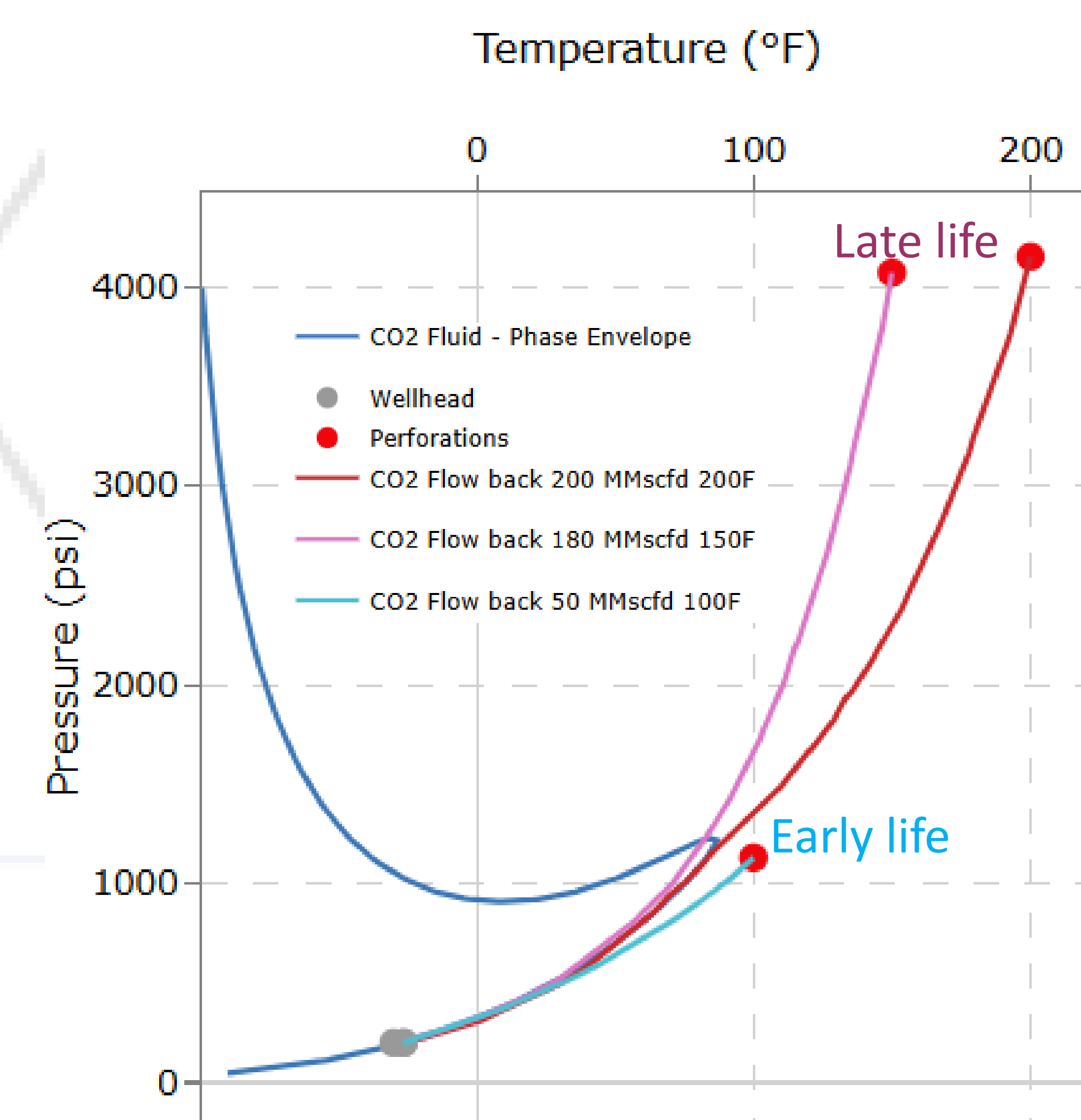
Sections	Bottom (ft MD)	OD (in)	WPF (ppf)	ID (in)	Wall (in)	Drift (in)	Grade	Ratings	Grade / Connection
	8,700.0	7	23	6.366	0.317	6.250	VM25S80	API	VM-25S-80 / VAM21

Pure CO₂ mixture composition and phase envelope:

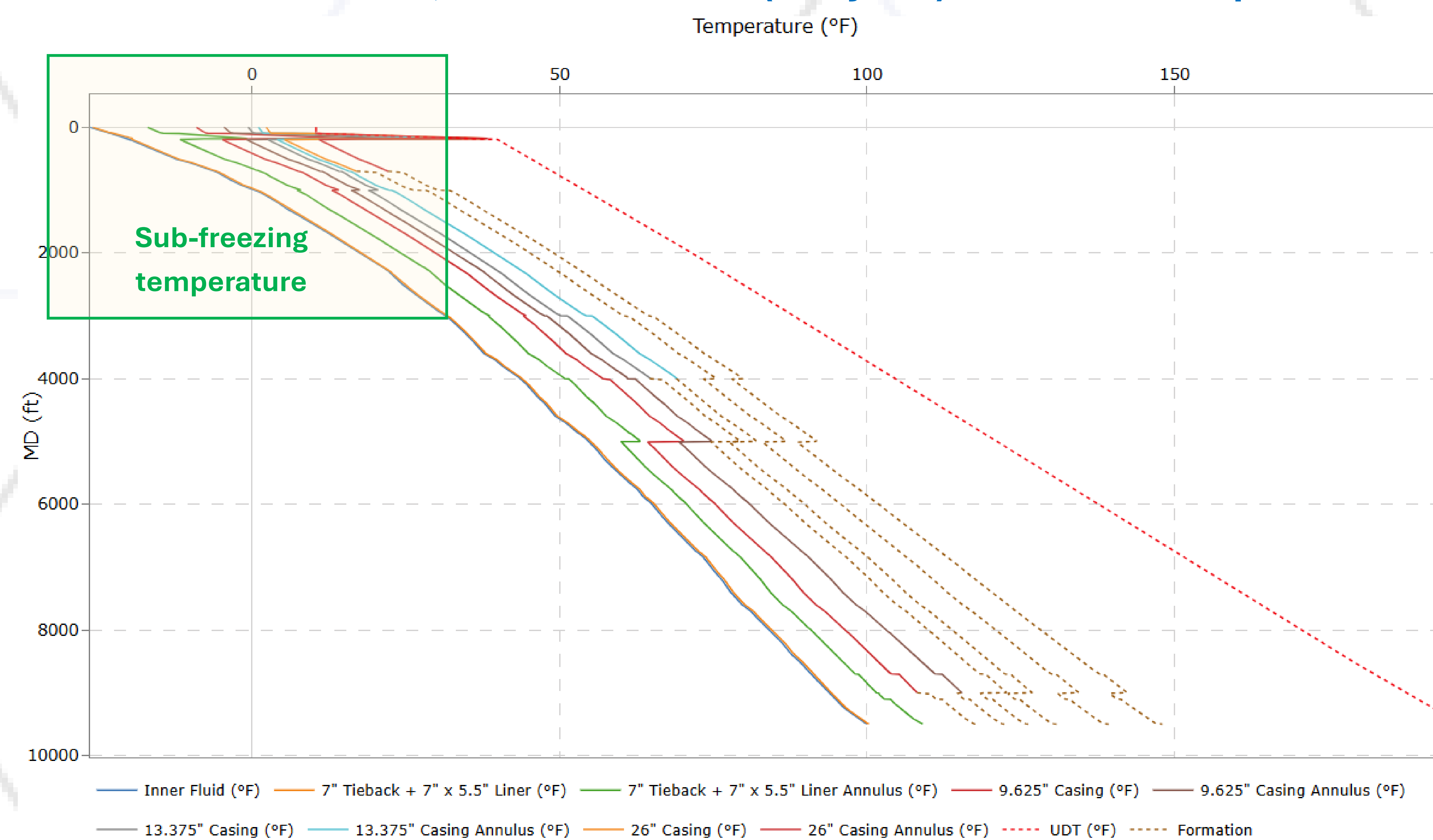


- CO₂: 96%
 - Ar: 0.002%
 - H₂S: 0.002%
 - N₂: 1.5%
 - CH₄: 0.49%
 - H₂O: 0.005%
 - H₂: 2%
 - O₂: 0.001%
- Total impurities: 4%**

CO₂ injection - Operation Paths



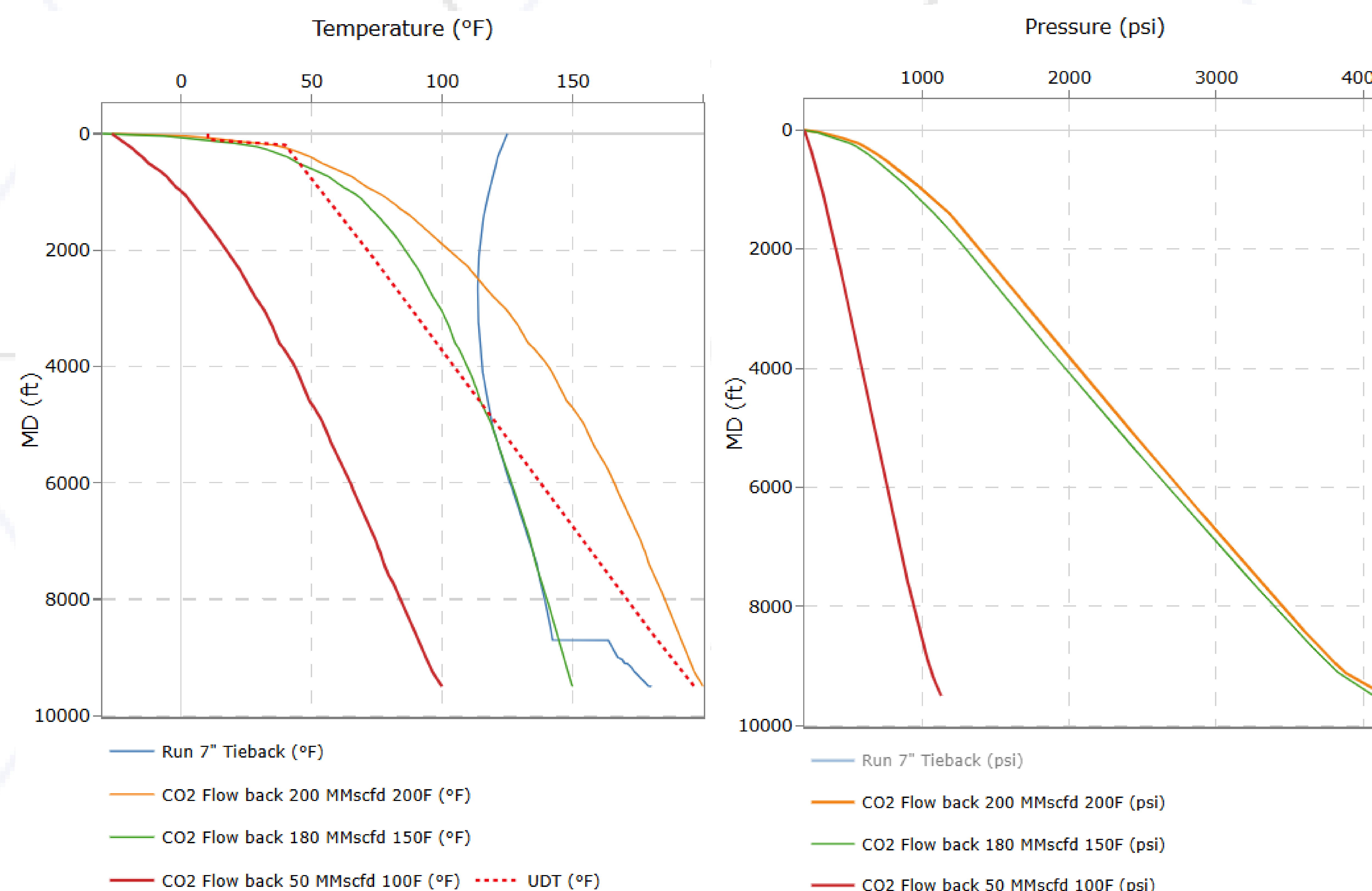
CO₂ flowback, 50 MMscfd 100F (early life) - Wellbore temperature



3 FLOW ASSURANCE - CO₂ DISCHARGE FLOW:

- GERG 2008 EOS
- Reservoir recharged pressure: ~1000 psi (early life), ~4000 psi (late life)
- Uncontrolled discharge at atmospheric pressure
- Flow duration: up to 30 days

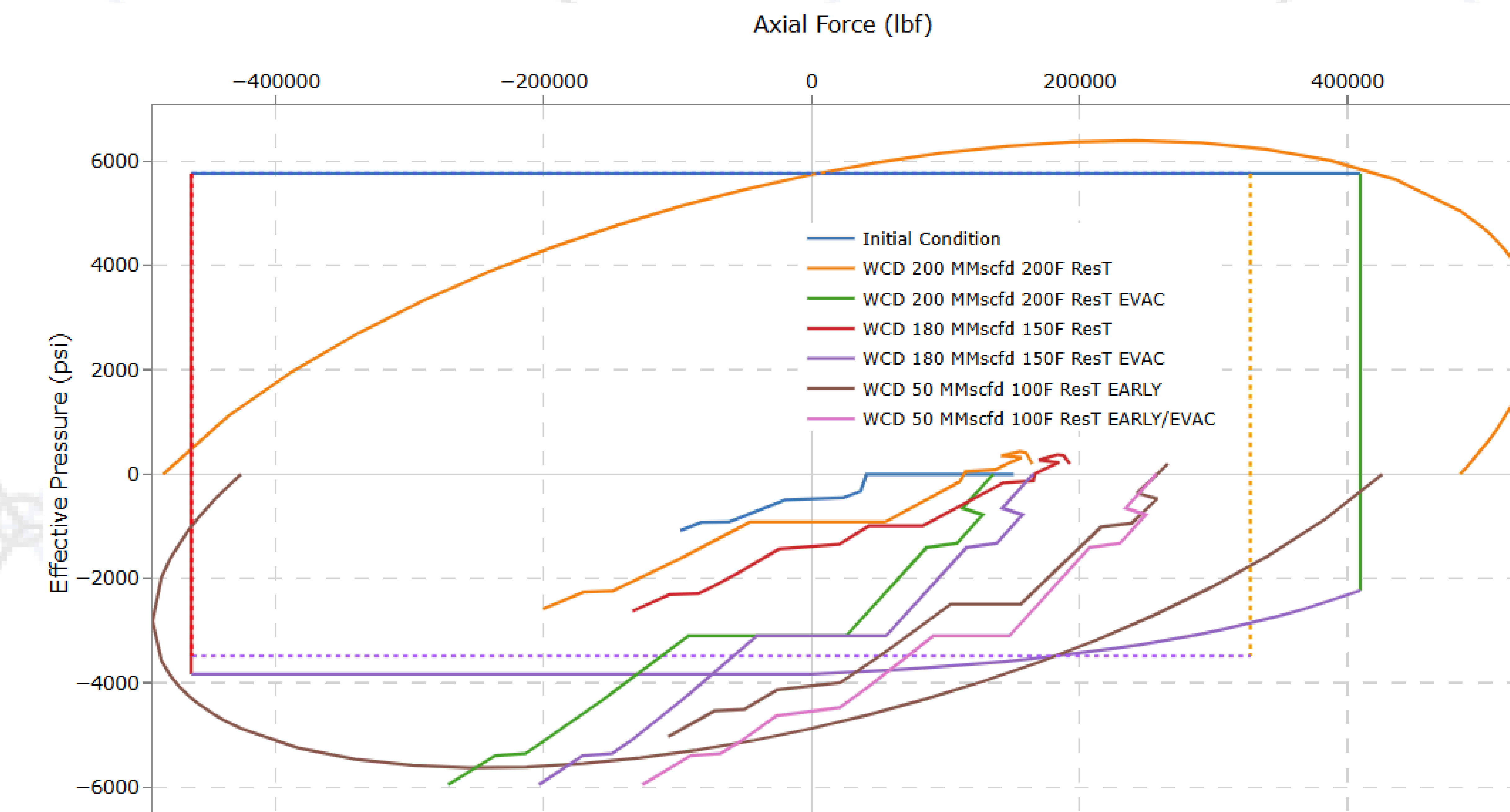
CO₂ injection - Fluid Temperature and Pressure



4 LOADING CONDITIONS AND STRESS ANALYSIS

- Wellhead and hangers exposed to sub-freezing temperatures
- 7" tieback subjected to:
 - CO₂ flow pressure/temperature effects
 - Full evacuation in case of formation plugging
- 9 5/8" casing subjected to:
 - CO₂ flow temperature effects

DLP—7" tieback - flow and evacuation loads



DLP—9 5/8" casing - flow and evacuation loads

