Alternate Gas Lift Tracer Pilots

Radioactive / Minimum Concentration Tracers

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Outline

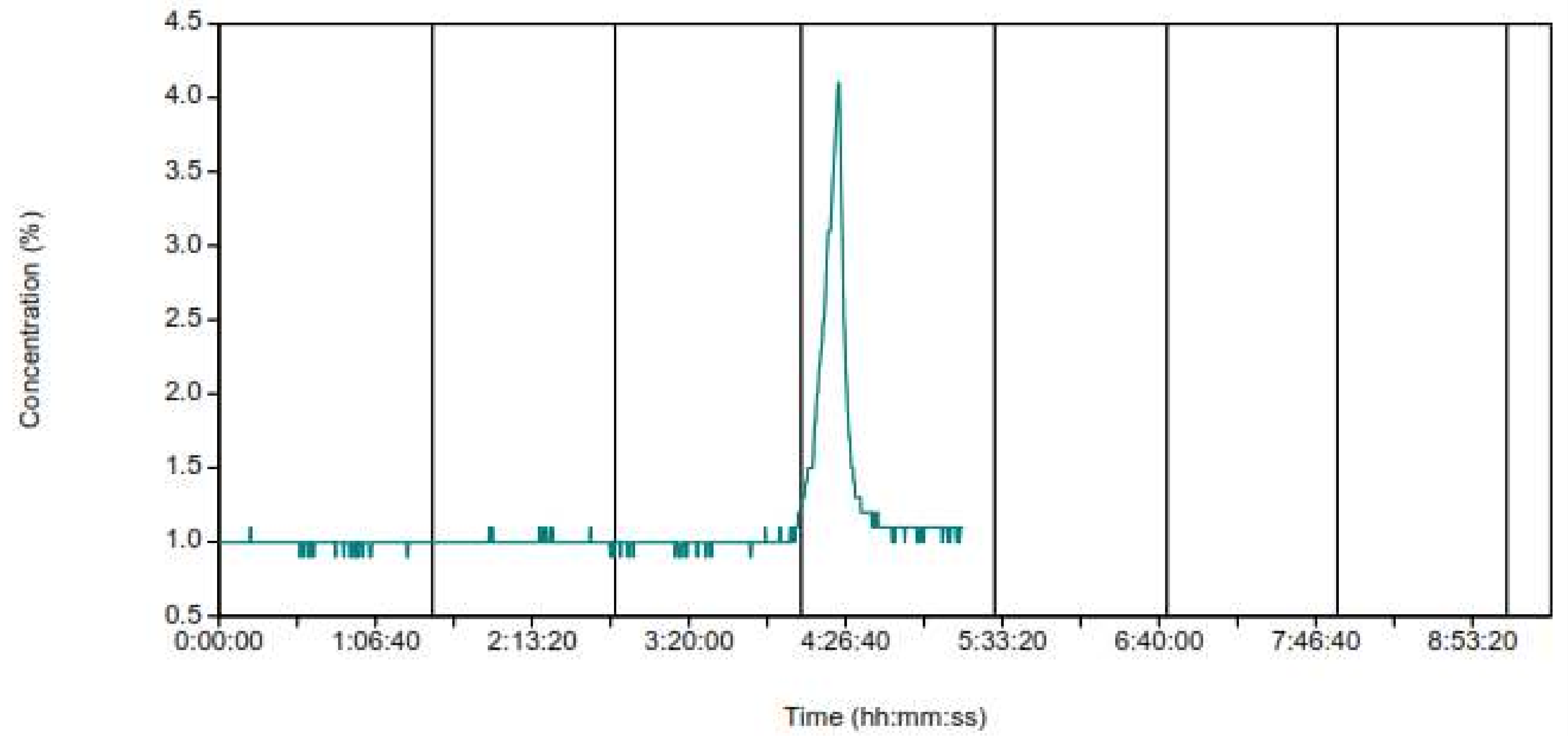
Background

- CO_2 Tracing
- Alternate Tracing

Pilots, Round 1

- Hawkins
- Radioactive (RA) Tracing
- Minimum Concentration Tracing

Next Steps

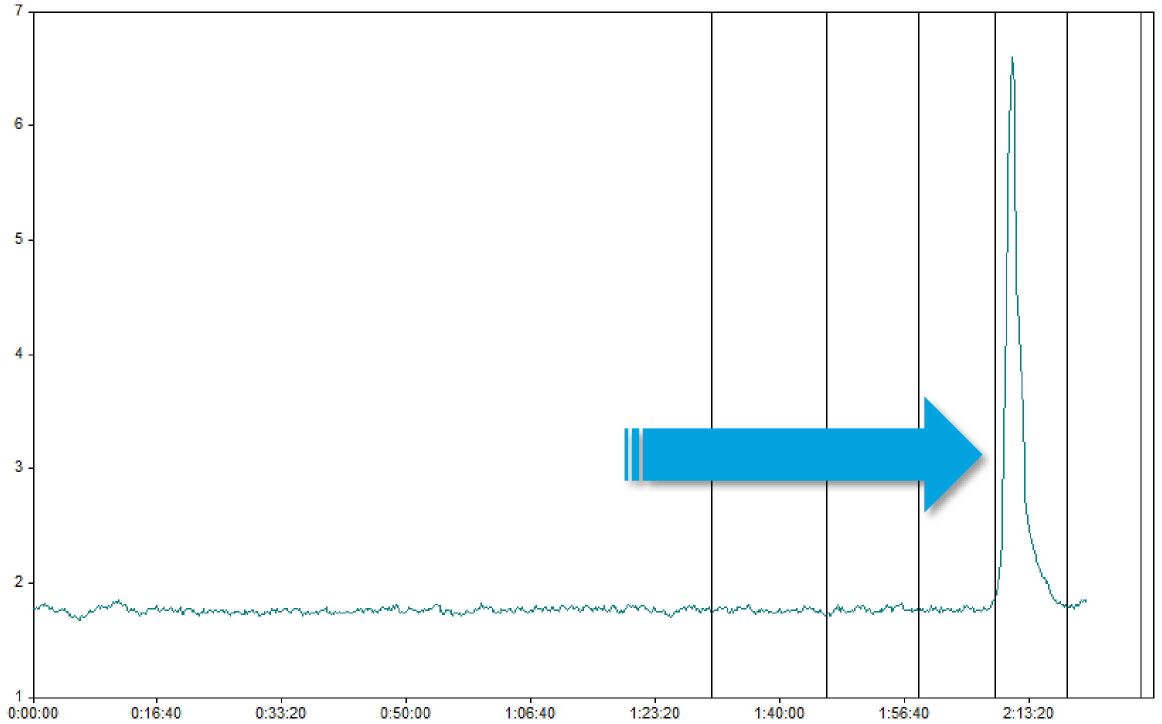


Background

CO_2 Tracer Surveys – Overview

WellTracer®

- Inject a slug of CO_2 with GL gas
- Detect CO_2 returns with gas chromatograph
- Real-time data plus nodal analysis determines communication depth(s)
- Preferably at GL valves but could be a hole
- EM has run CO_2 tracer surveys for ~20 years
- (See References)



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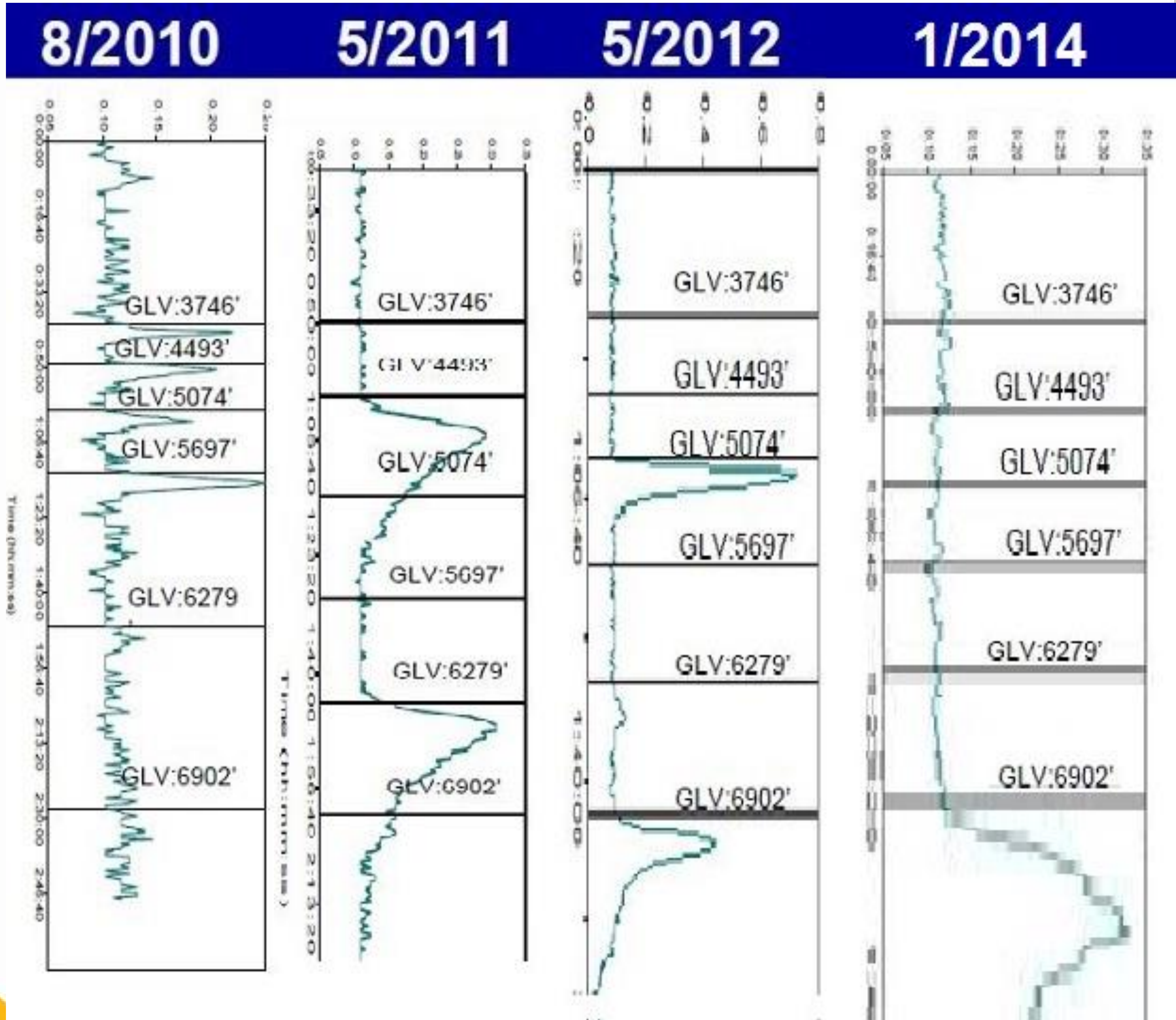
CO_2 Tracer Surveys – Example

8/2010 – Well multipointing at first five mandrels; injection rate 43% higher than design

5/2011 – Injection rate reduced to design, lift at second and fifth mandrels

5/2012 – Multipoint injection at 3rd, 5th, and 6th valves; valves redesigned

1/2014 – Redesigned valves (ports and pressure settings) and reduced injection rate by 46%; production increase of ~550 BOEPD



CO_2 Tracer Surveys – Pros/Cons

Advantages
- Interventionless determination of communication points
- No production impairments during survey
- Field proven, commercial equipment

Disadvantages
- Potential freezing issues due to sampling line (East Canada, Bakken, North Slope)
- Need enough CO_2 (pph) to overcome natural background (North Slope)
- Need enough pressure to inject into the GL gas stream (3000 psi in East Canada)
- Logistics of measurement unit, CO_2, N_2 (for pressurization), hoses, laptops, etc.
- Considerations for area classification, exhaust stream, SIMOPS

Potential Improvements

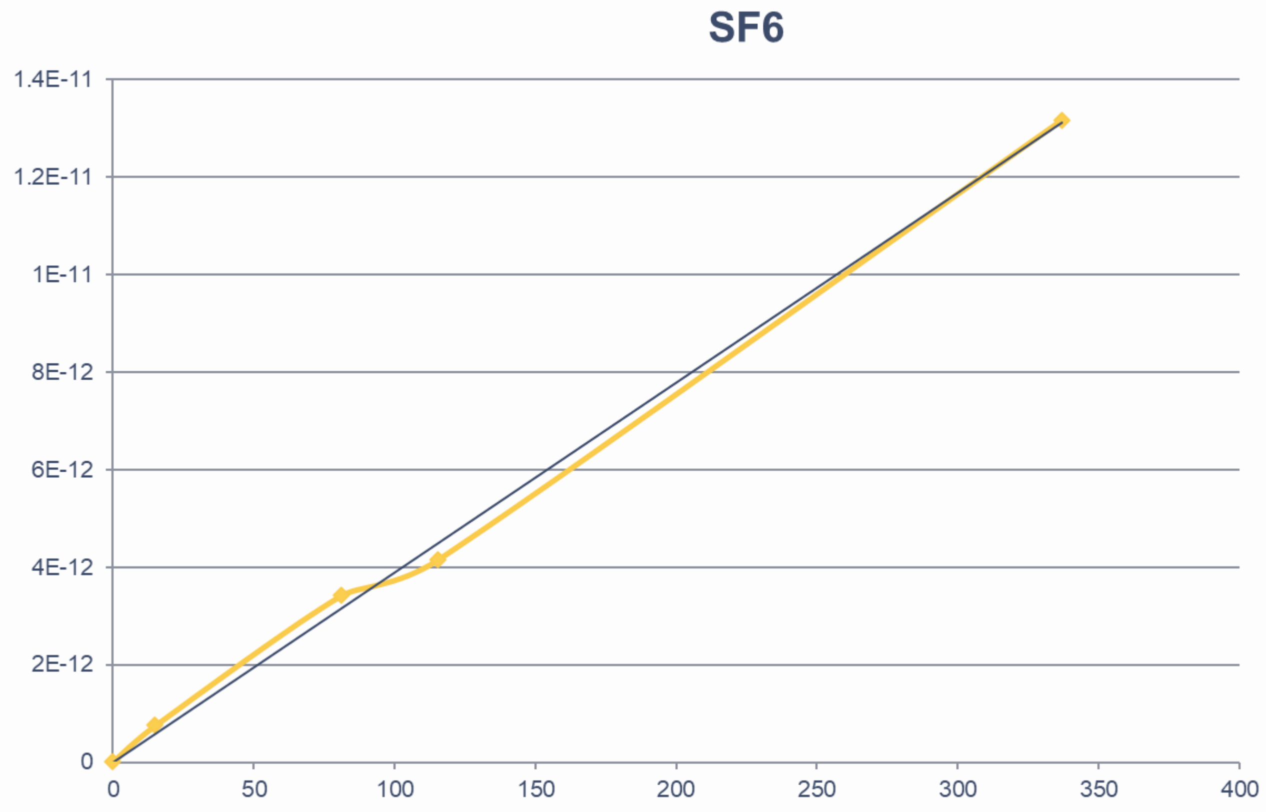
Tracerco Kr-79

Radioactive Tracer

- Hire somebody with a license!
- Inject the gas tracer with the GL gas
- Measure it through the flowline (no sampling!)
- High measurement sensitivity, shorter half-life, and dilution mitigate safety concerns

Minimum Concentration Tracer

- Inject something inert and alien to production wells
- Use a high-res (ppb/ppm) mass spectrometer (MS) to sample
- SF_6 recommended (common in facilities tracing)
- Argon easy to find but too close to hydrocarbon spectra, as confirmed with sample testing at Inficon



Lab Testing – ppm

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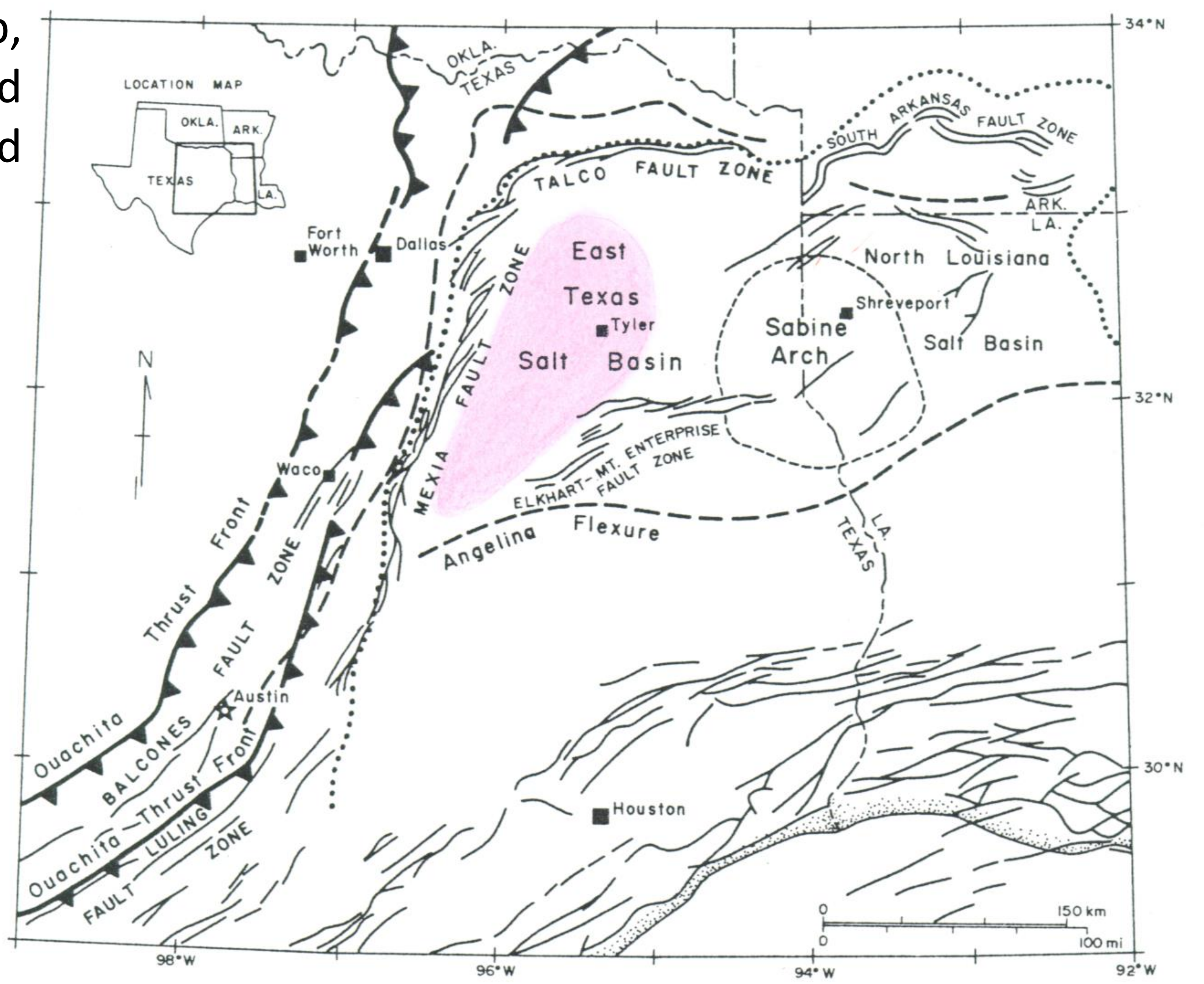
Hawkins Field

Hawkins Field

USGS Map, Hawkins field shaded



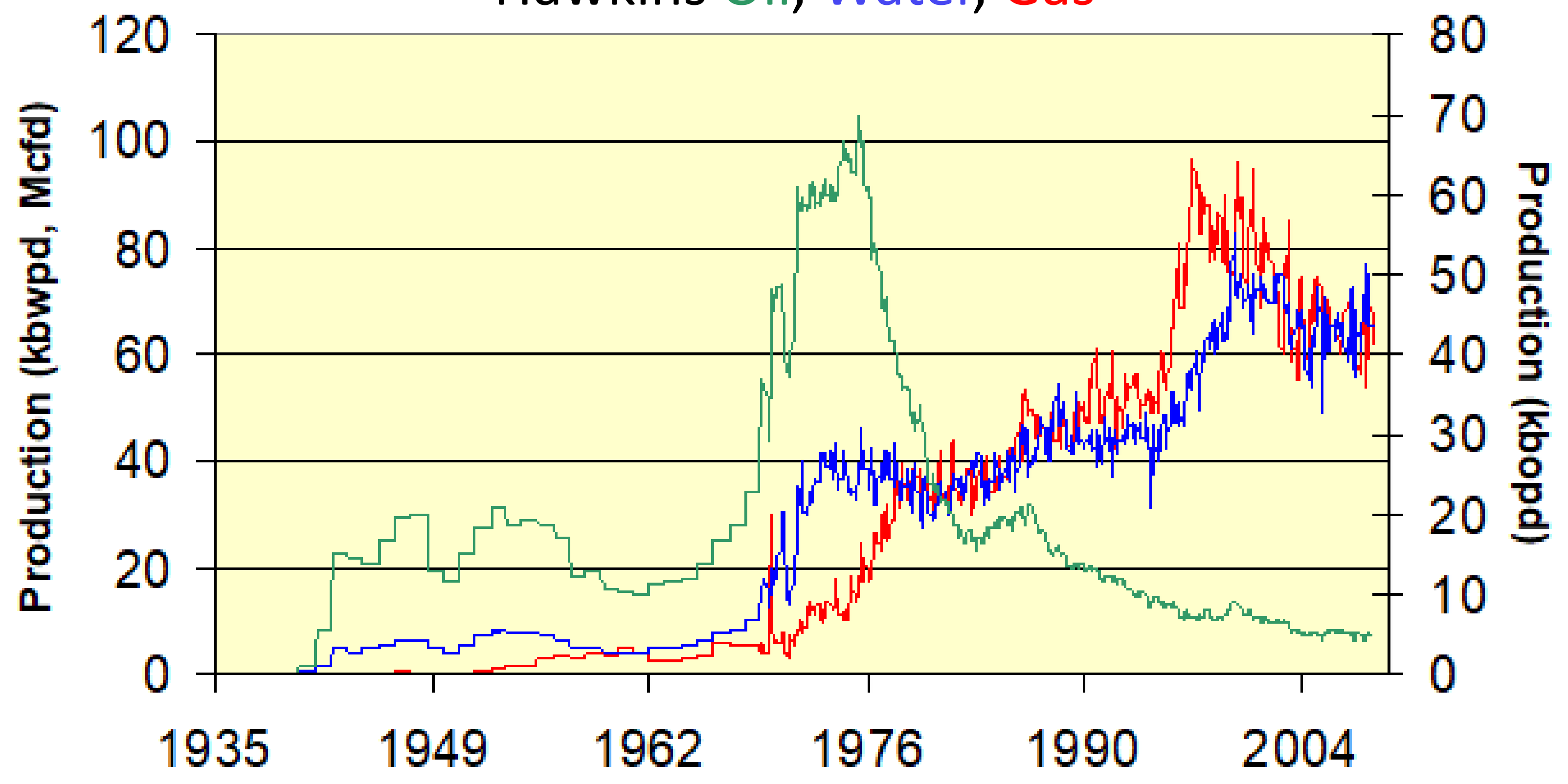
History

- East Texas conventional, producing since 1940s
- Initially strong water drive (1st), then gas drive (2nd)
- Double displacement process since 1994 (3rd)
- Heavy oil with "asphalt" mat
- Bail water and inject gas to keep oil at perfs

Artificial Lift Methods

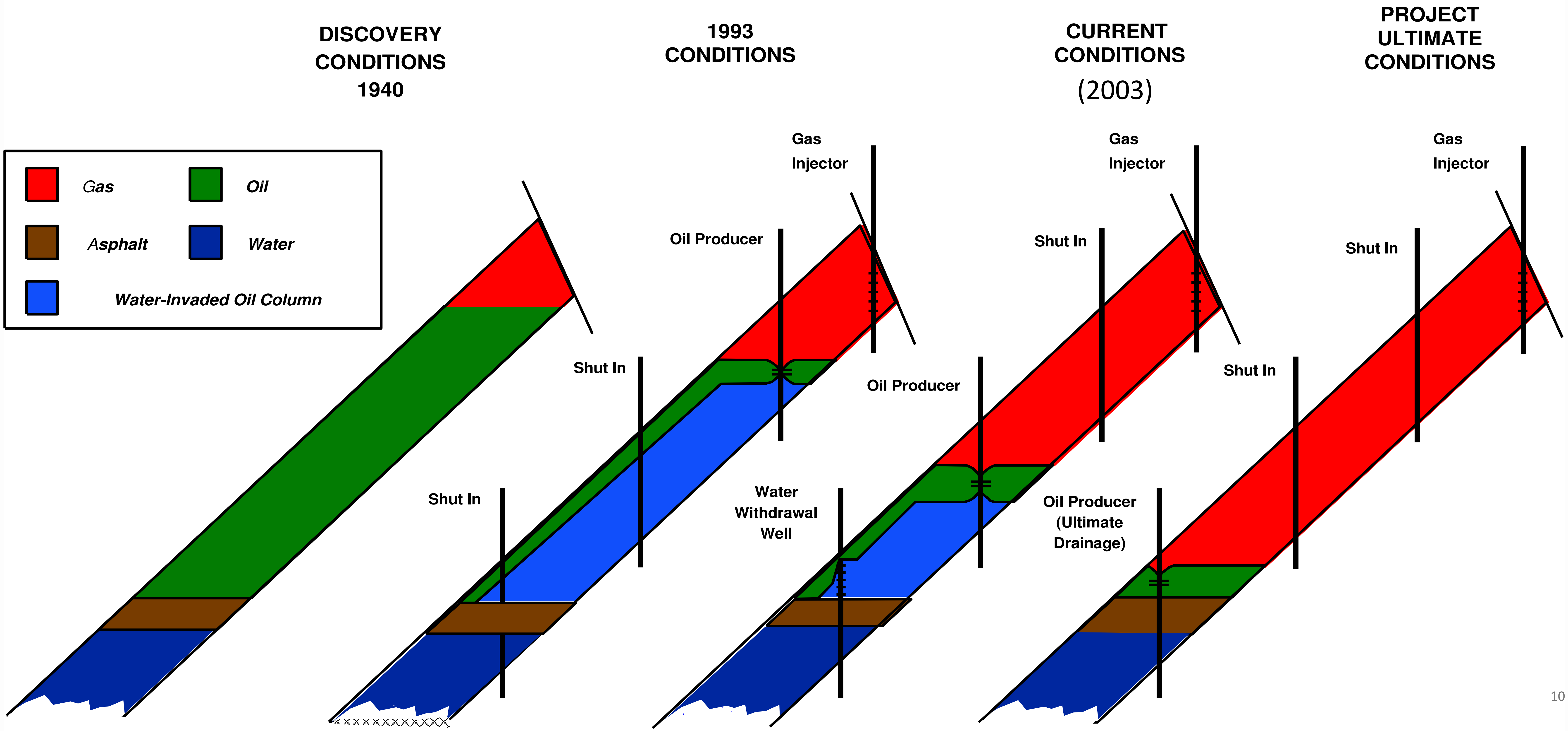
- Gas Lift (mostly N_2!)
- ESPs
- Jet pumps (few)
- Plungers (briefly)

Hawkins Oil, Water, Gas

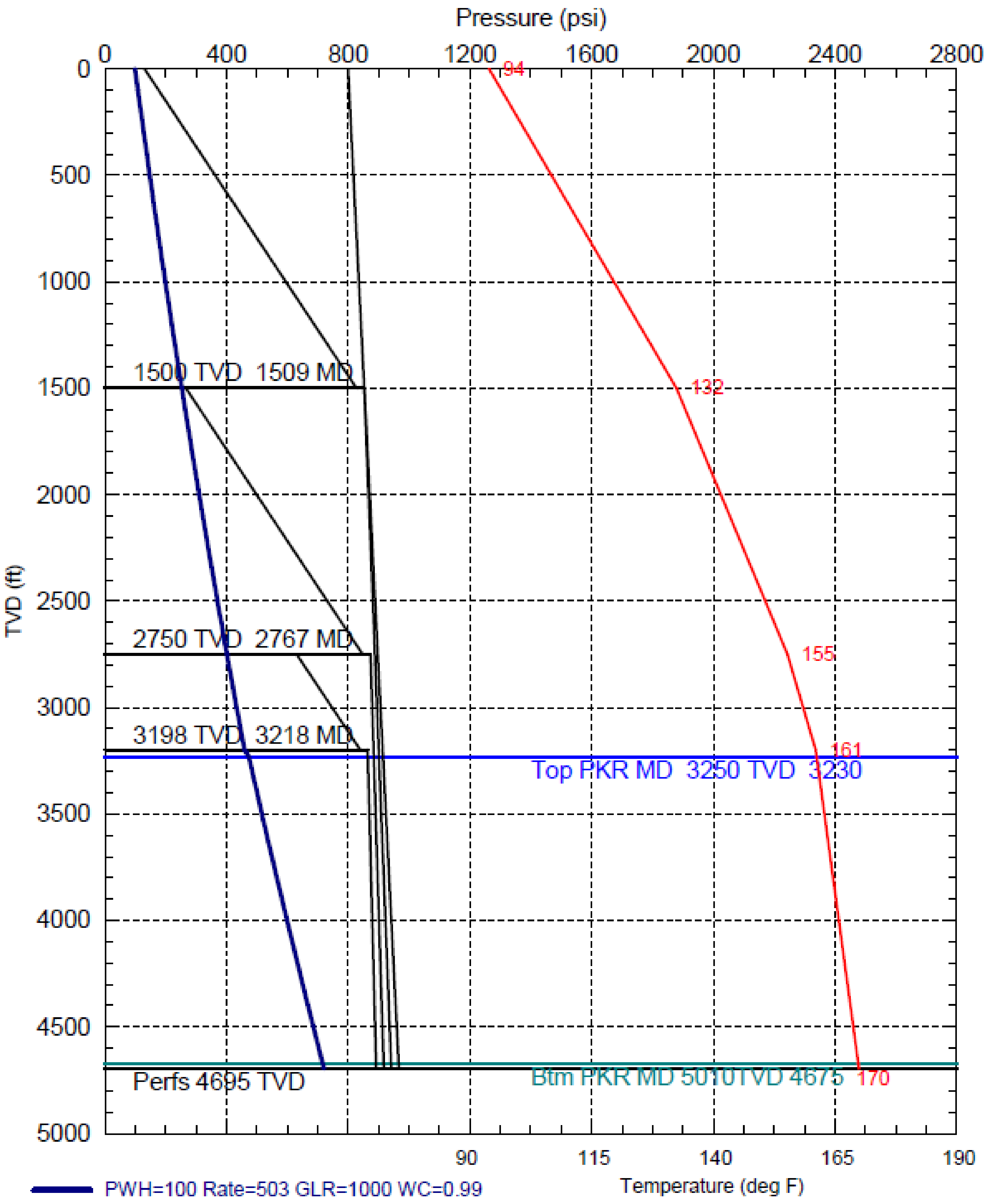


SPE-81459-MS

Hawkins Double Displacement Process

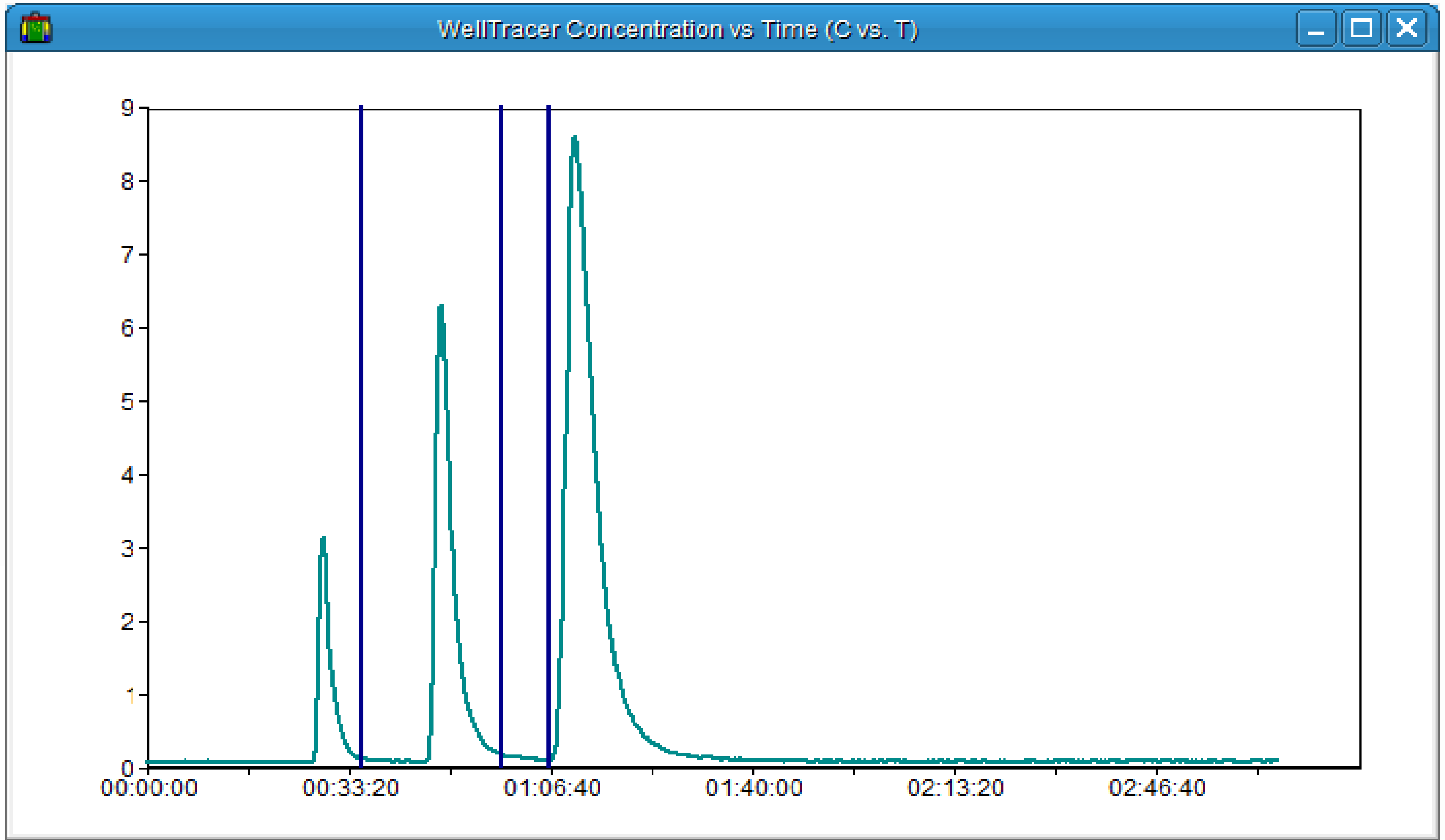


Hawkins #1 Pilot



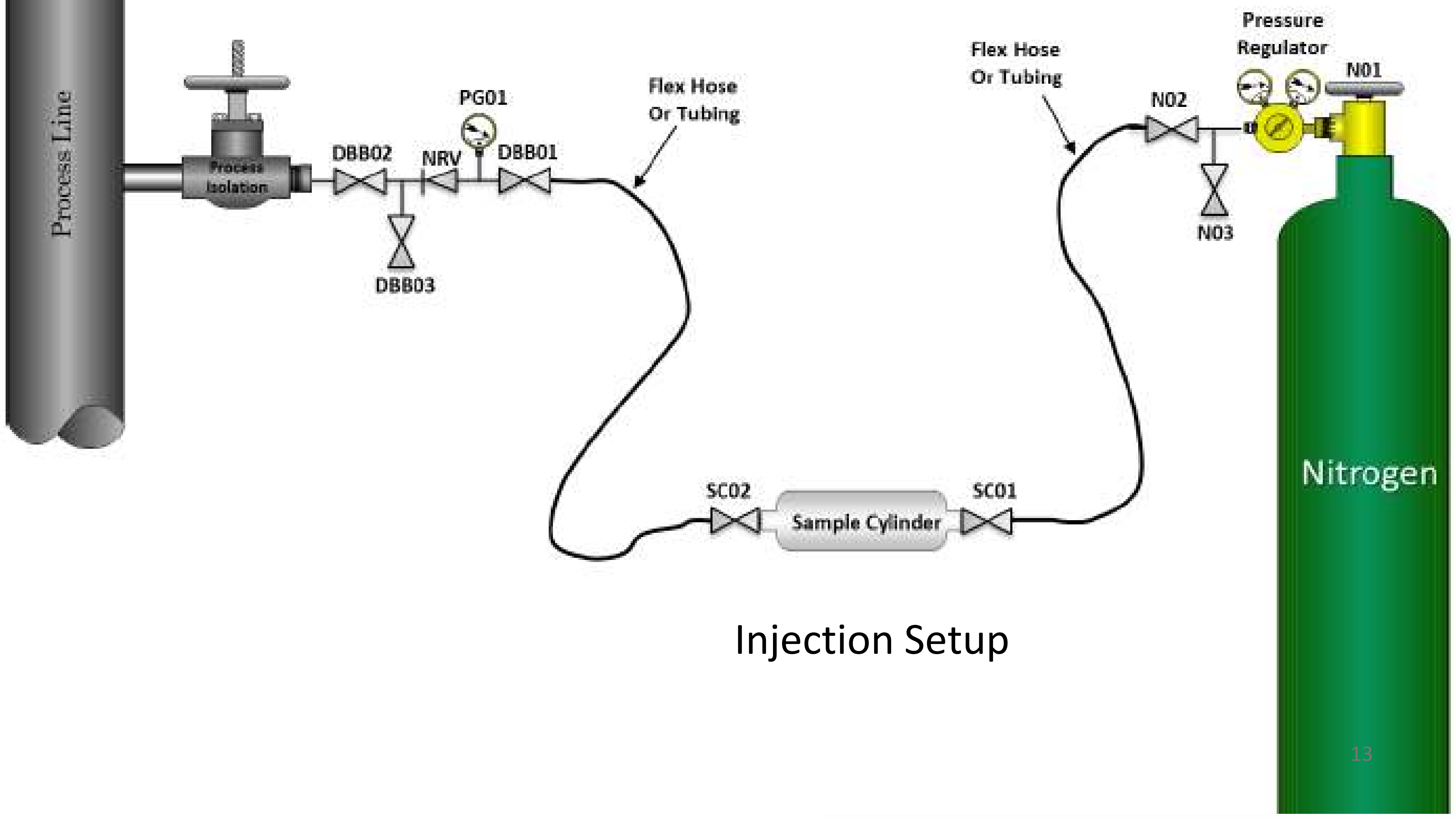
Hawkins #1 Baseline

- < 100BPD liquids, ~480 MCFD GL gas
- Three 12/64” IPOs, no orifice
- Nodal: Top valve closed, middle valve in transition, bottom valve open
- CO_2 Tracer: All valves taking gas, WHP was ~260psi due to stuck choke



Hawkins #1 RA Tracing

- Kr-79 sourced from Missouri reactor
- 35hr half-life, so only 3-4 days to complete surveys
- (Other longer-lived isotopes are available for tracing)
- 10cc (50mg) of Kr-78 in ampoule sent to reactor; only a small amount is converted to Kr-79



Injection Setup

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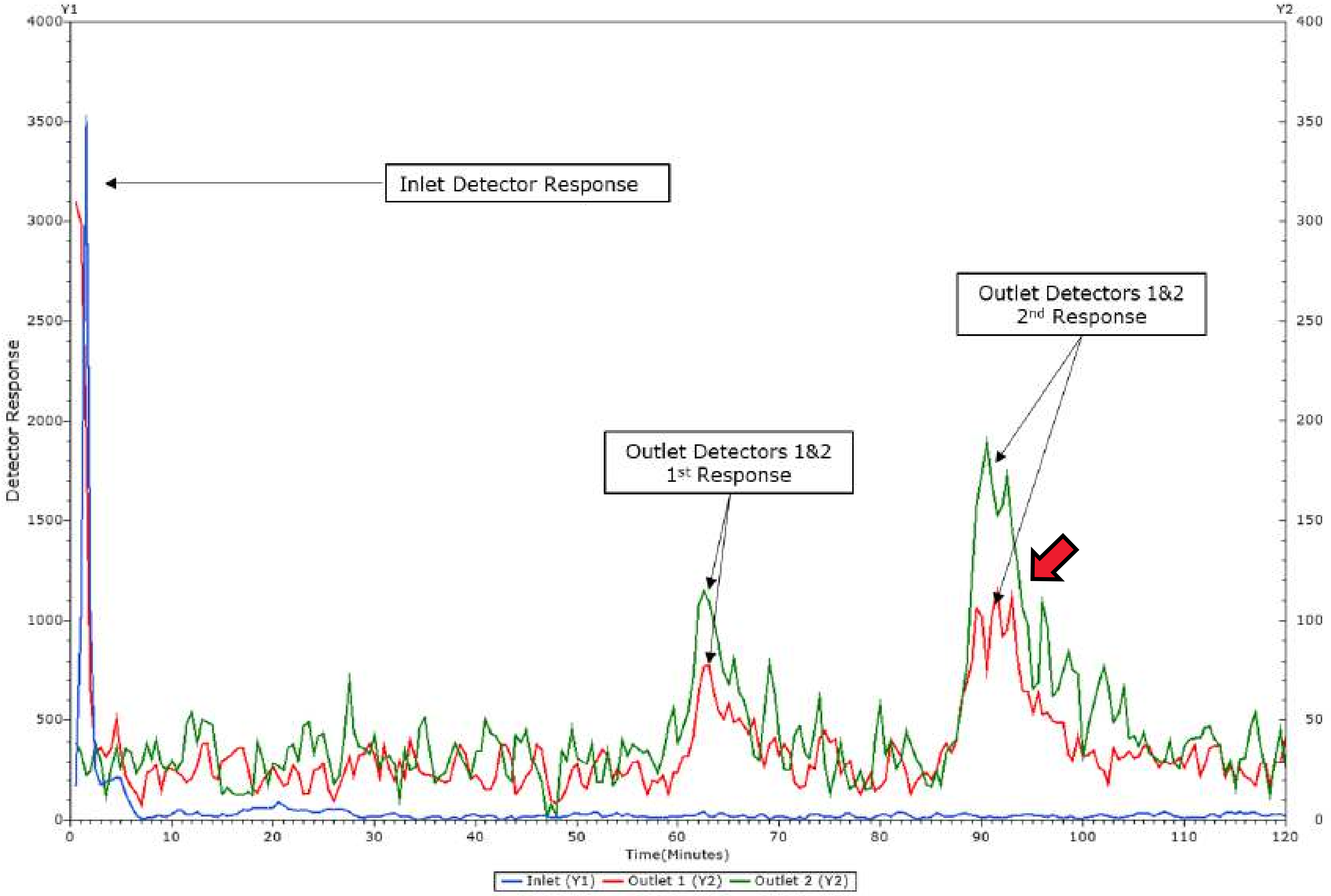
Hawkins #1
RA Tracing

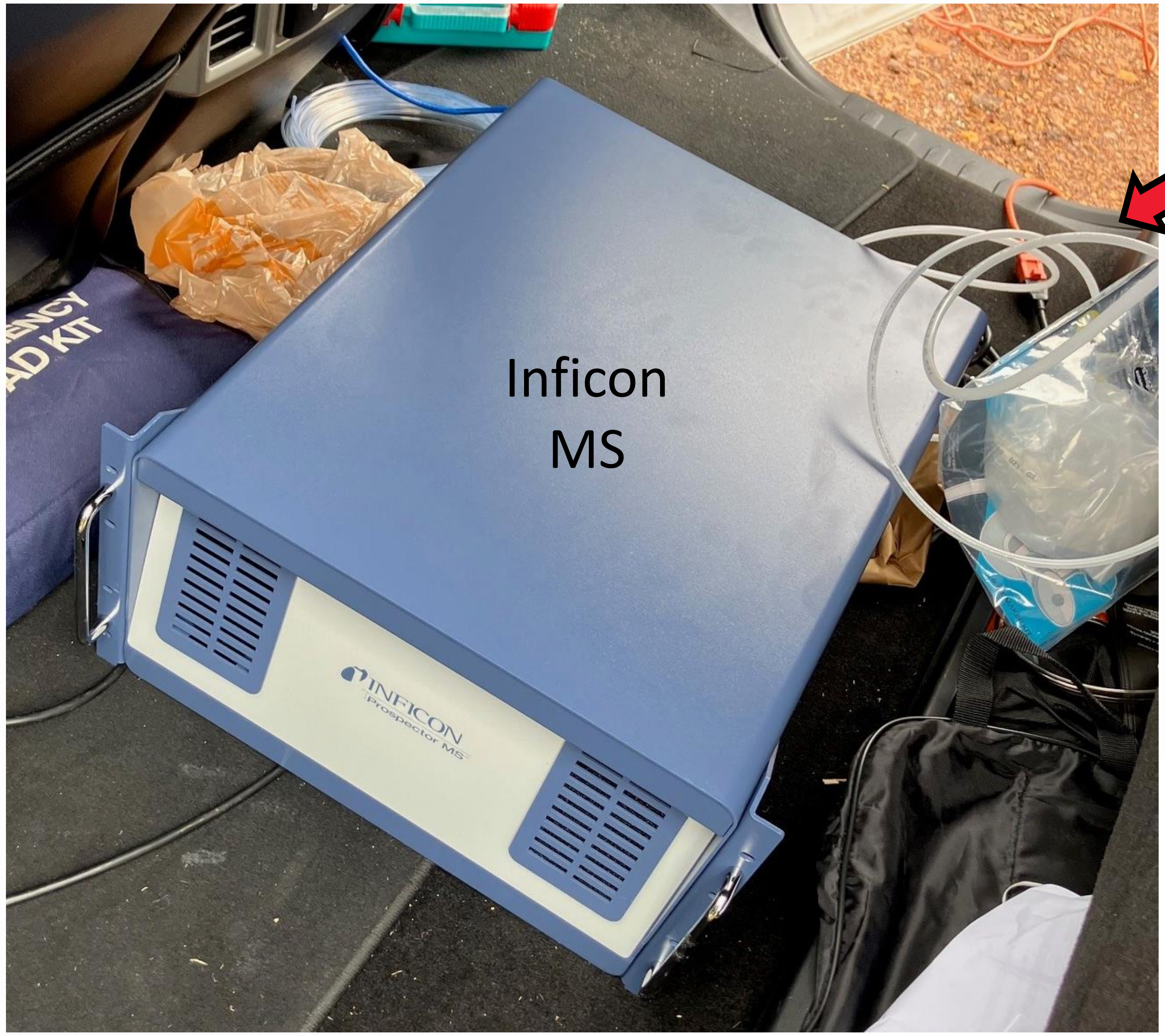
Wireless Radiation Detectors at Inlet, WH Outlet and Flowline (shielded circumferentially to avoid noise)

Hawkins #1
RA Tracing

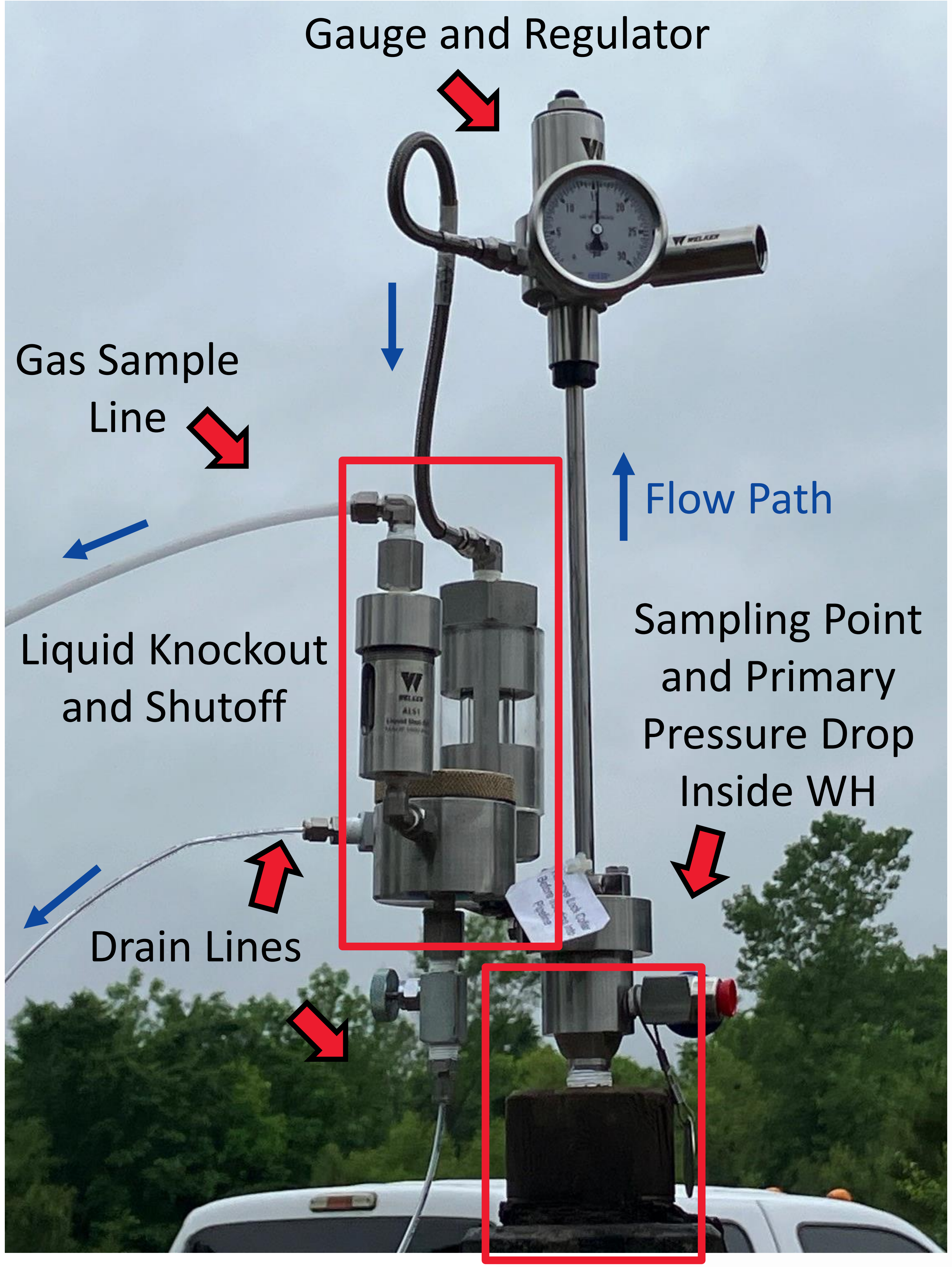


- Top valve closed, returns from valves 2 and 3, with more through bottom valve
- Choke had been opened and WHP had dropped to 110psi since CO_2 tracer run
- Noted well was producing more fluids with some slugs
- Hypothesized lower WHP helped close upper two valves
- **Results matched modeled nodal analysis predictions**
- **Tracer return times close to those seen with CO_2**
- Detector responses not identical because thicker WH steel attenuates more than stainless flowline

Hawkins #1
SF_6 Tracing

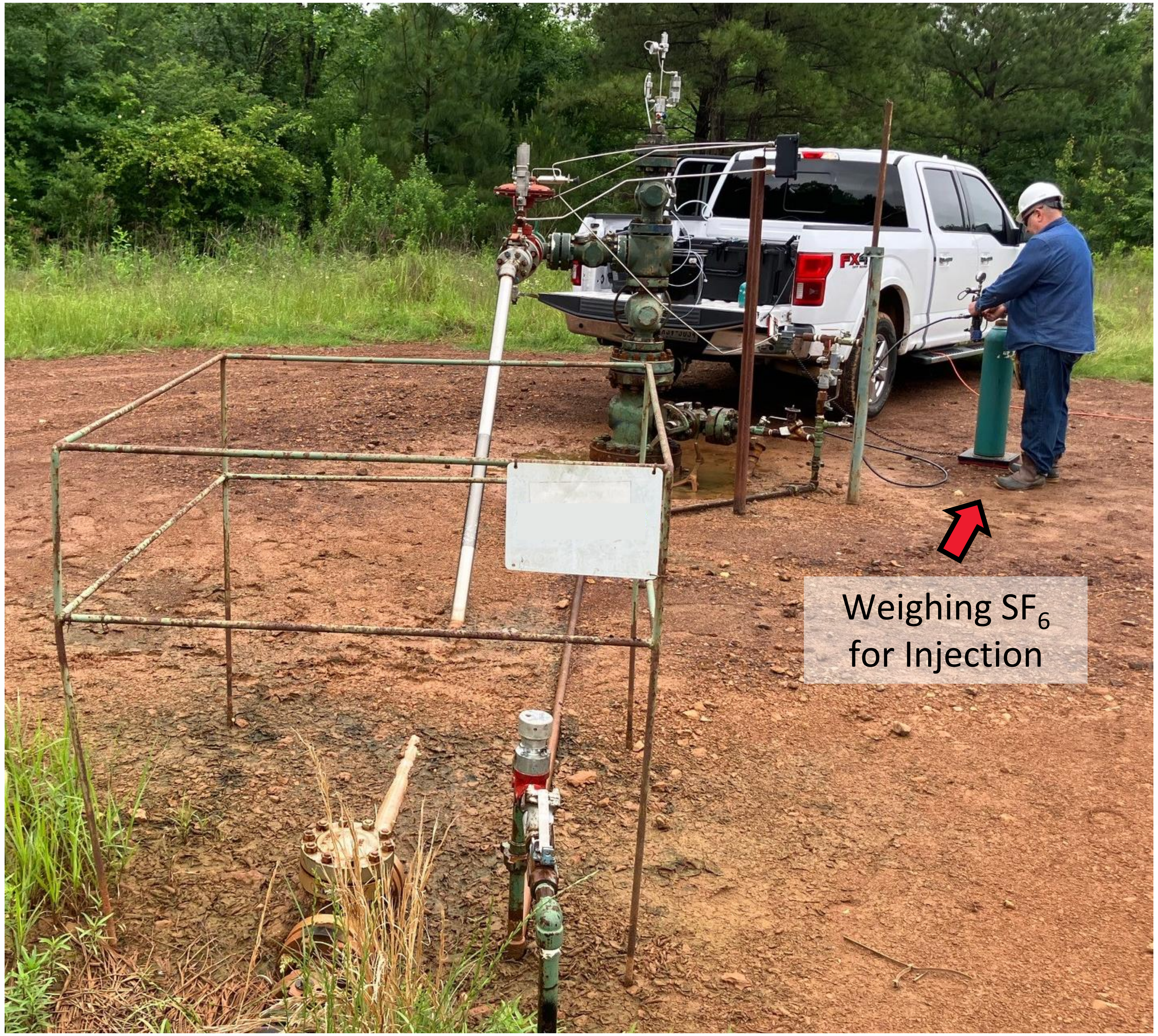


Sample Inlet



Welker Sampling Kit

Hawkins #1
SF_6 Tracing



- **SF_6 injected, but no returns detected**
- Determined afterward that dwell (sample) time was set too short for detection…after the fact
- Moved to next well due to limited SF_6

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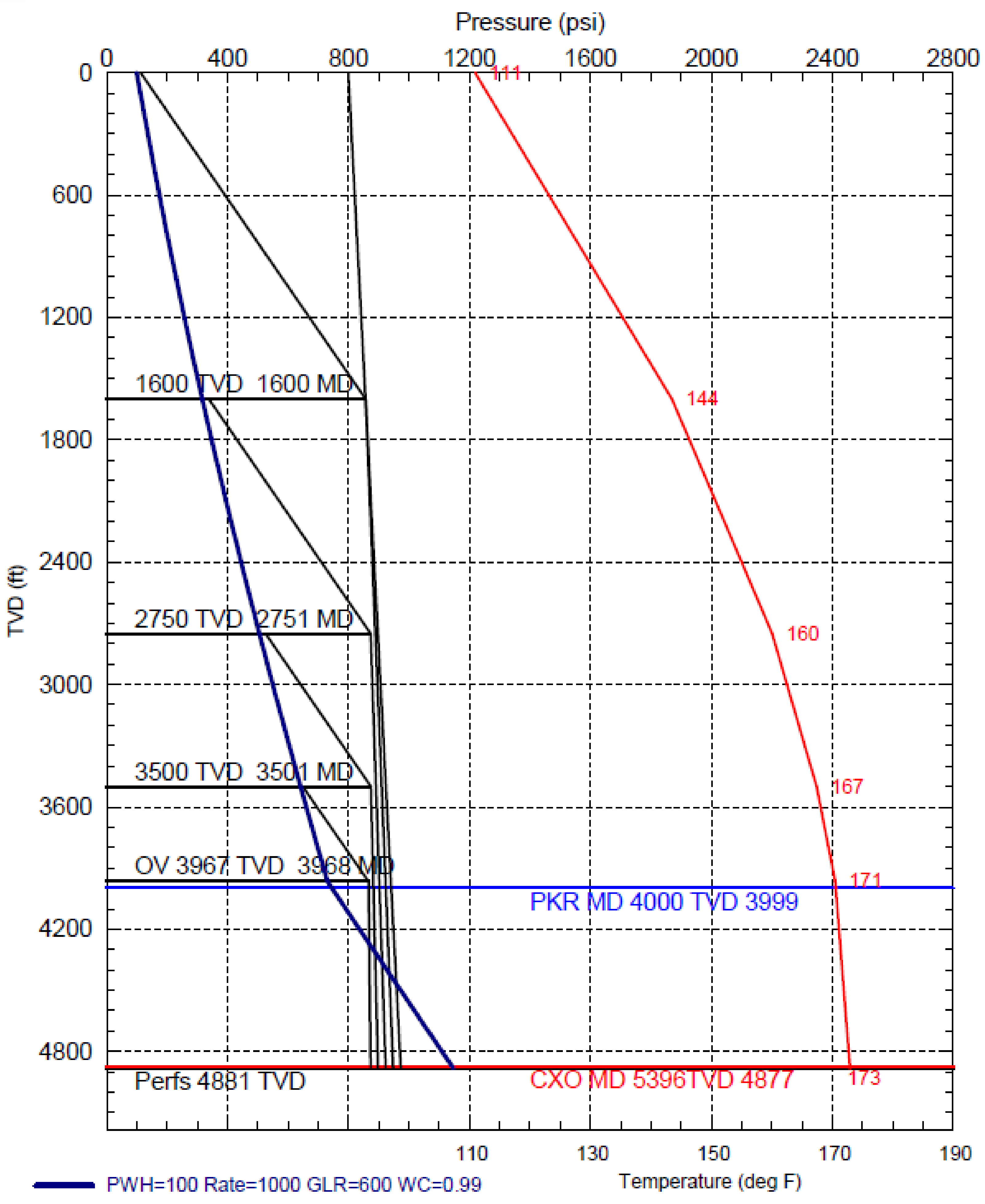
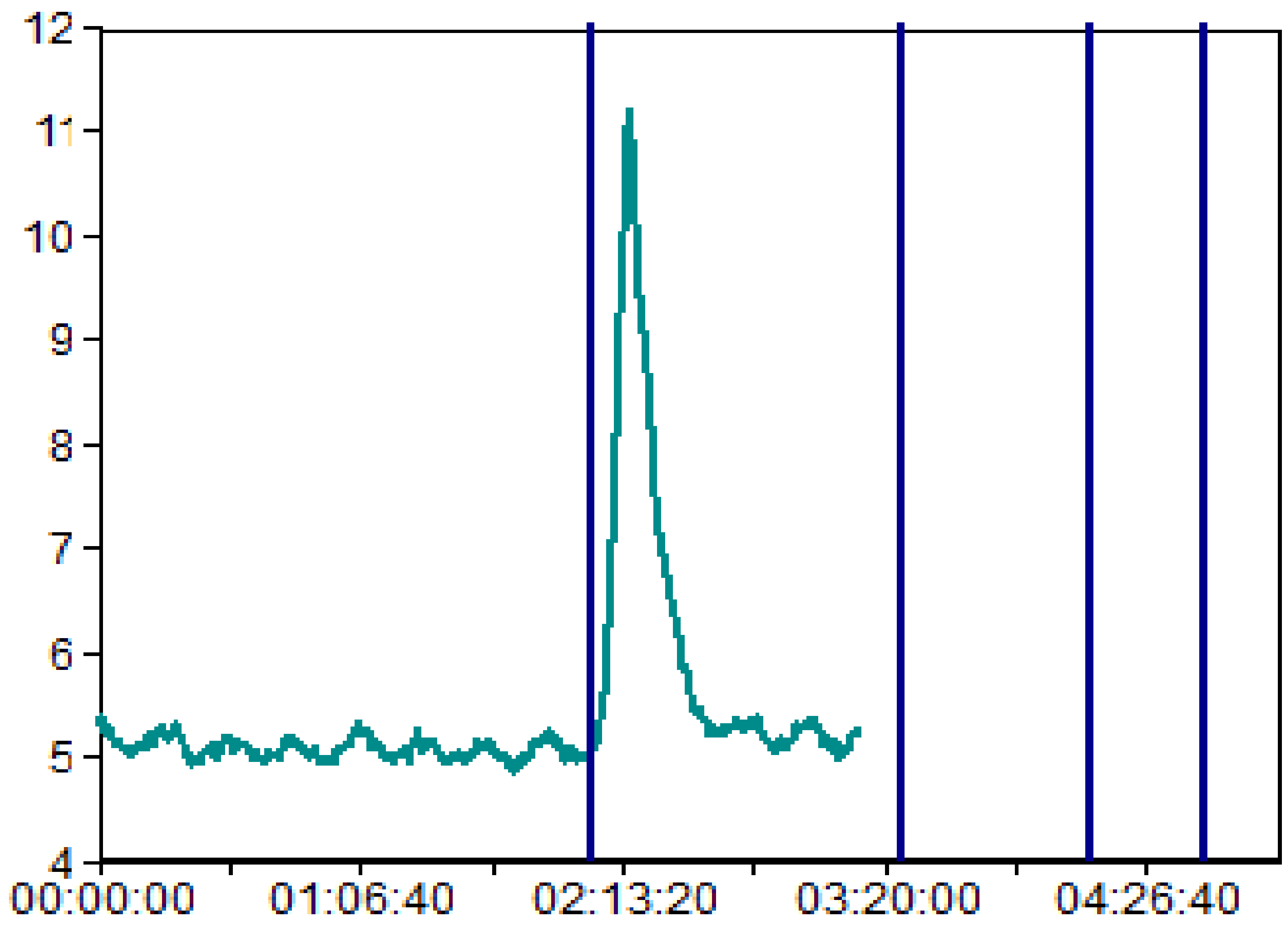
Hawkins #2 Pilot



Hawkins #2 Baseline

- > 600BPD liquids, ~300 MCFD GL gas
- Three 12/64" IPOs, One 16/64" orifice
- Nodal: All returns through top valve
- Acoustic Shot: Only top valve open, others liquid-covered (backchecked)
- CO_2 Tracer: All returns through top valve, trip time about 2hr



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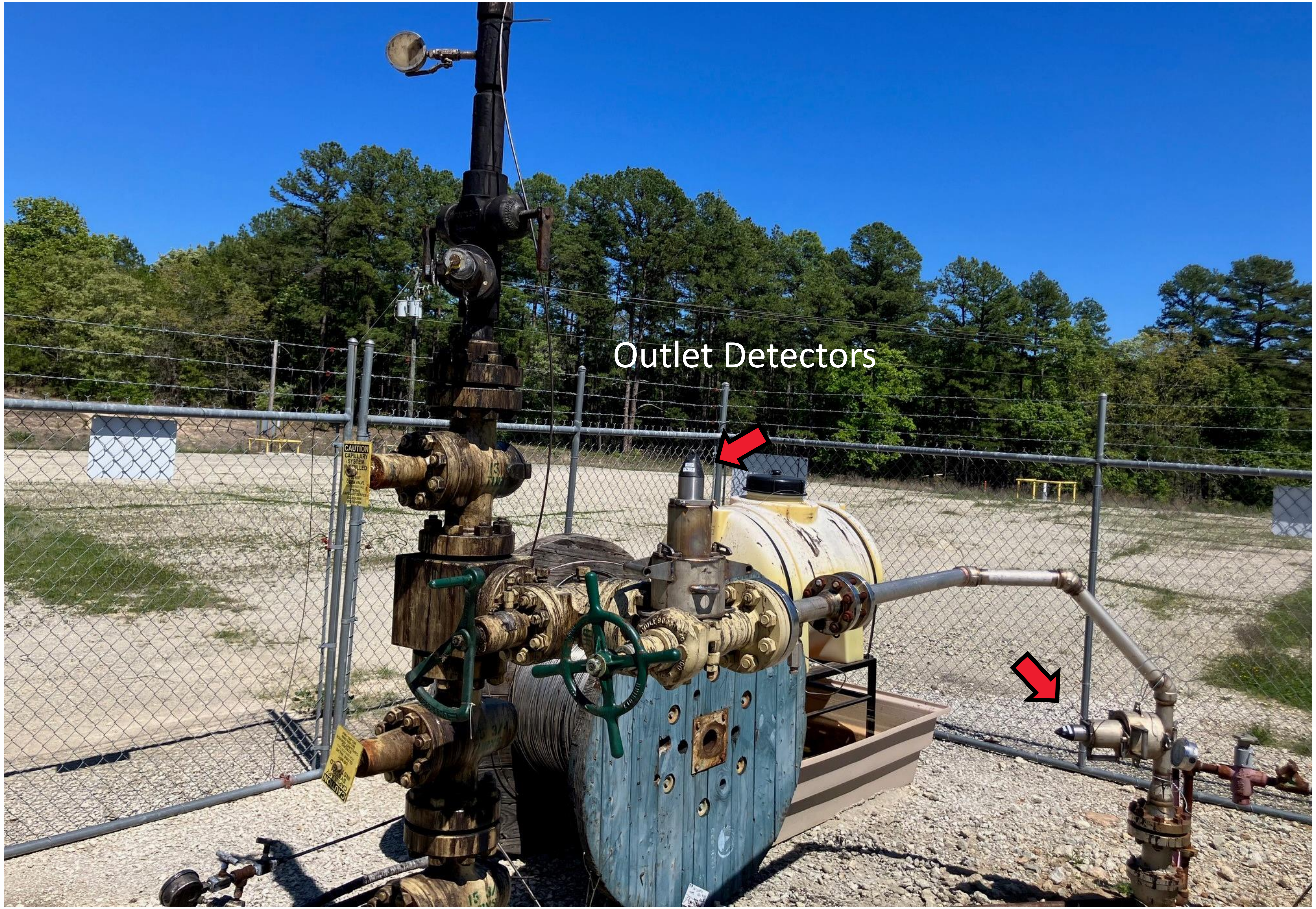
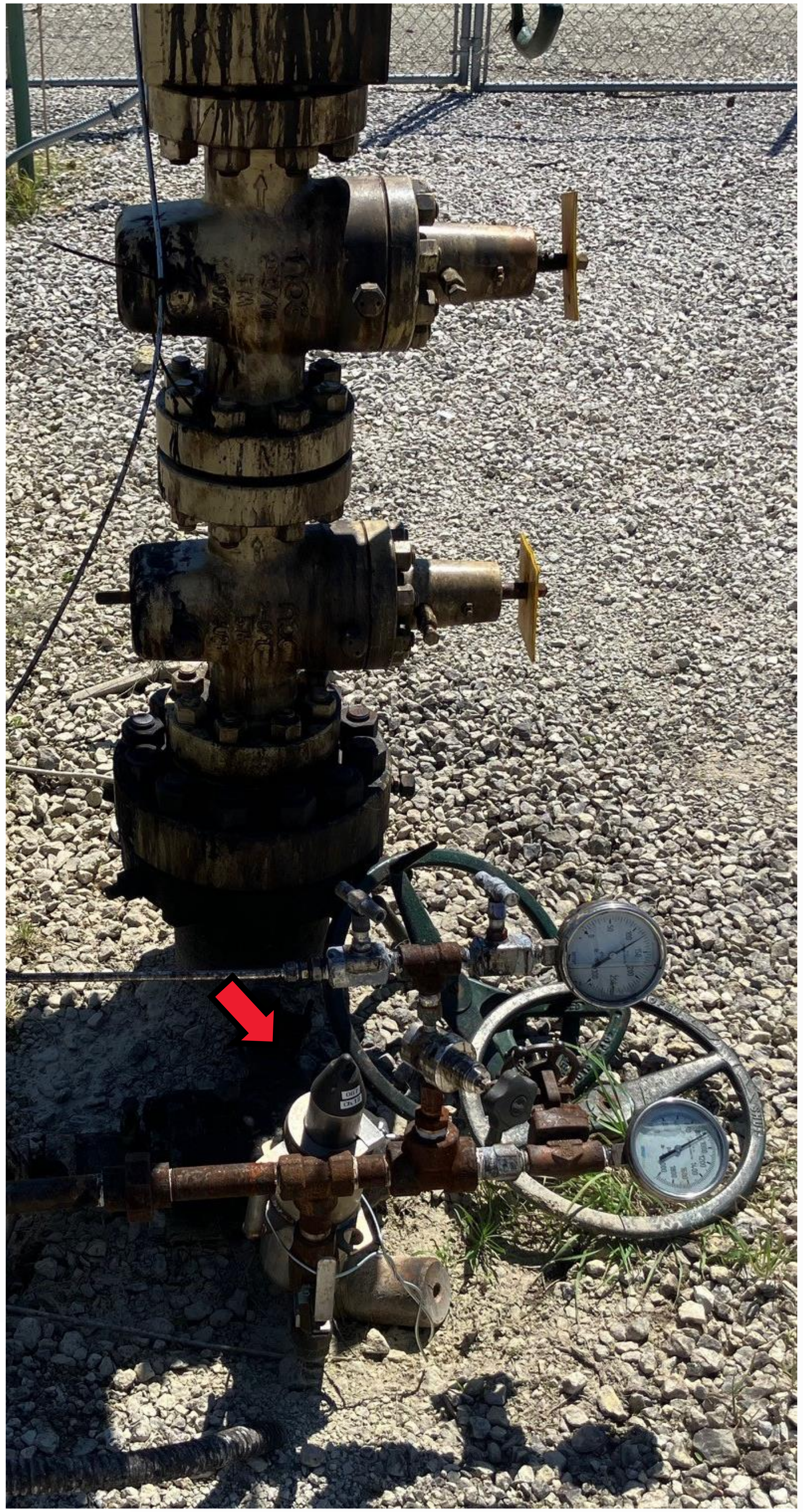
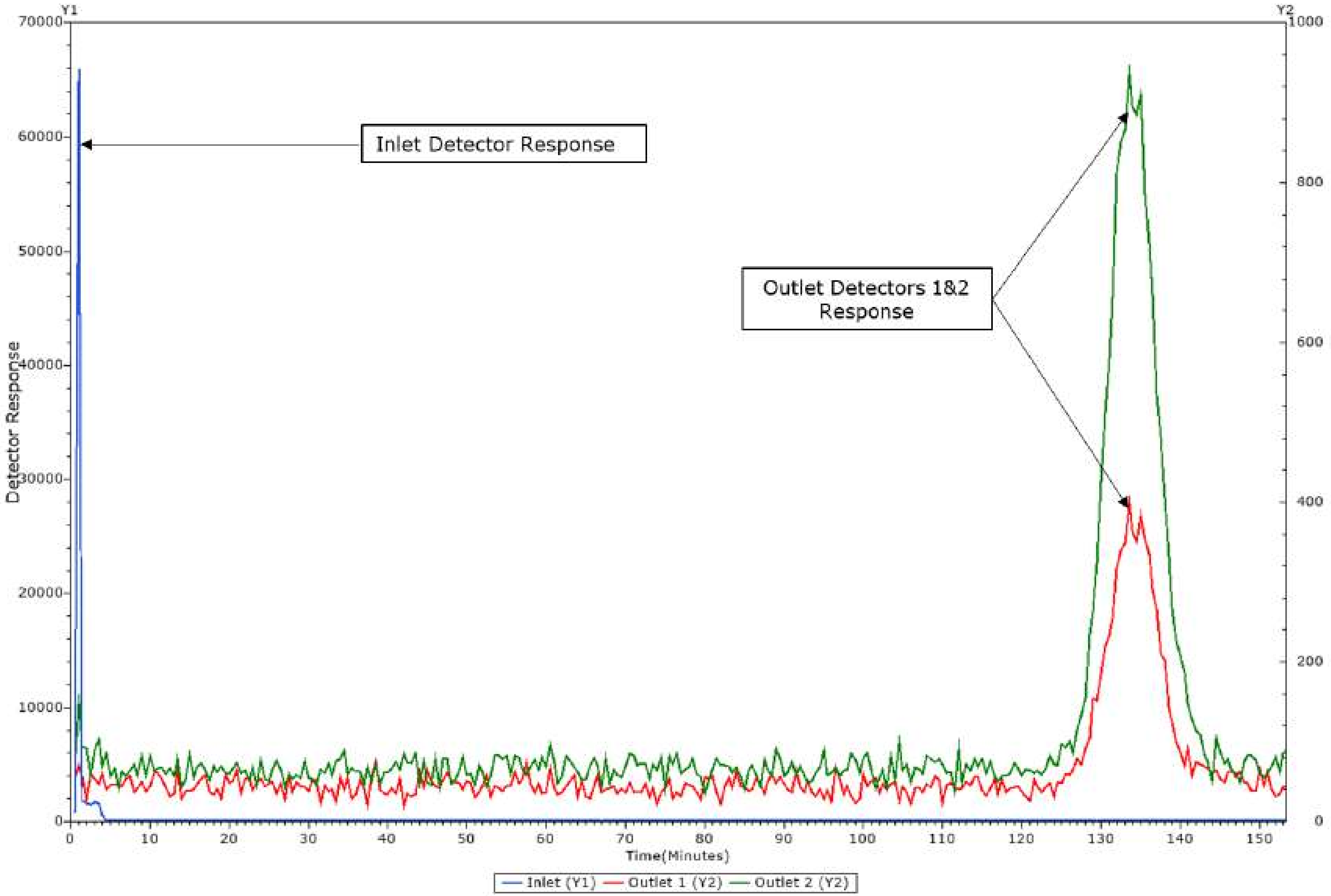
Hawkins #2
RA Tracing





Inlet Detector

Hawkins #2
RA Tracing

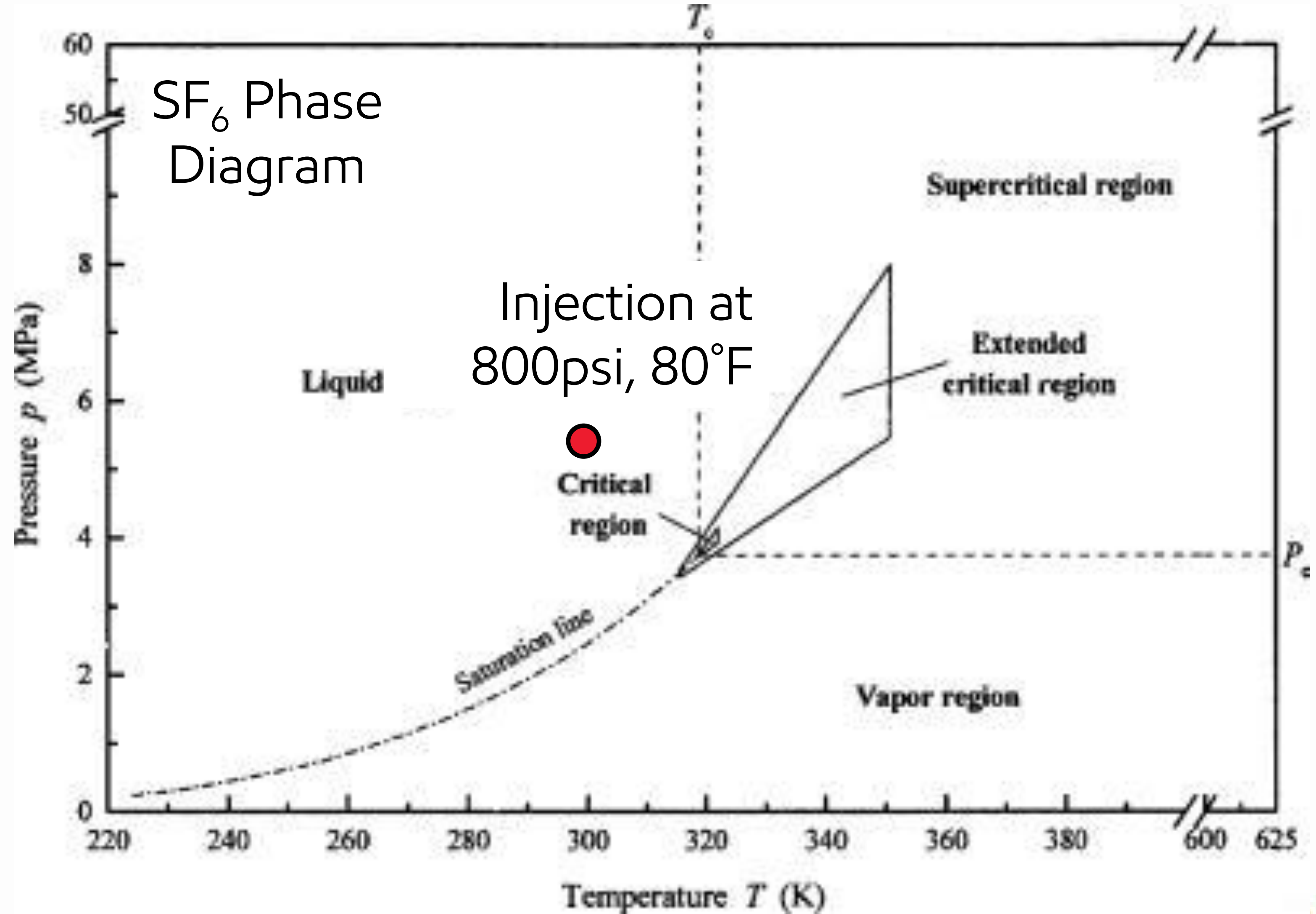


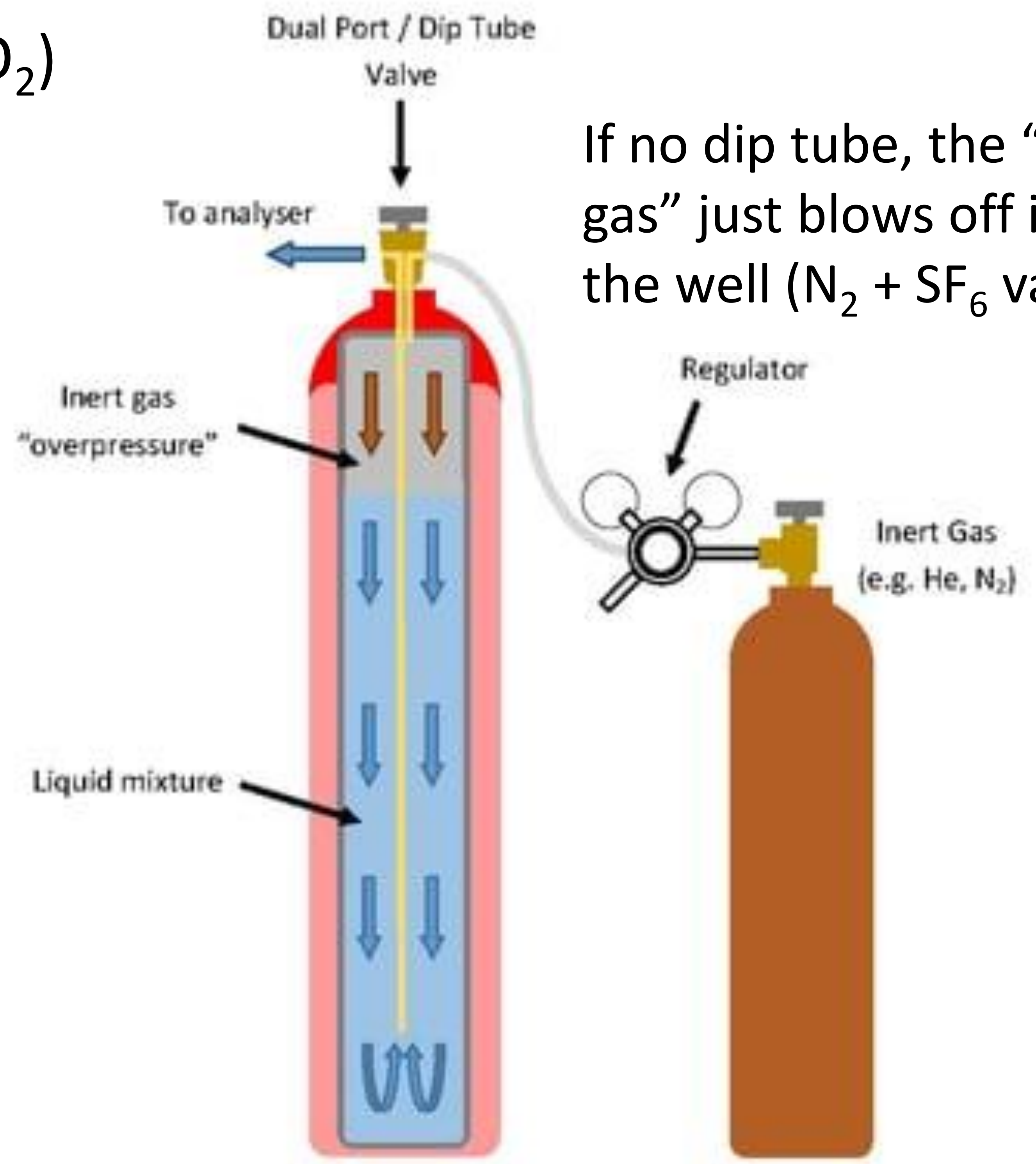
- Single return from top valve
- Same transit time as CO_2
- **Another match!**

Hawkins #2 – SF_6 Tracing

SF_6 vapor pressure at ambient temp. was about 350psi, unable to quantify mass injected

- SF_6 normally liquid at injection conditions (same as CO_2)
- Dip tube bottle enables liquid delivery when boosted with another high-pressure source (N_2 in this case)
- Dip tube bottle unavailable at testing location



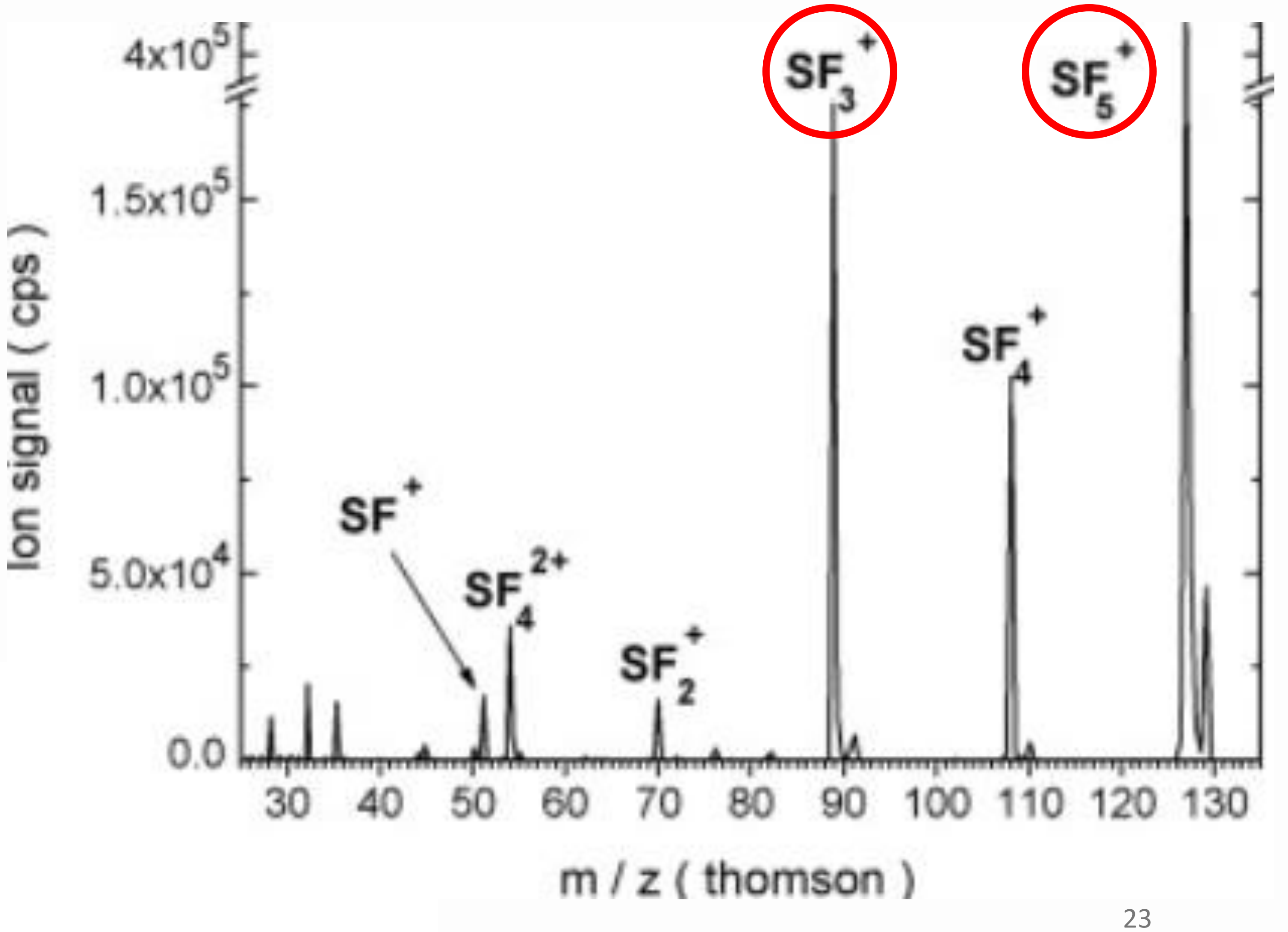


If no dip tube, the "head gas" just blows off into the well (N_2 + SF_6 vapor)

https://www.cacgas.com.sg/liquefied-gas-mixtures

Hawkins #2 SF_6 Tracing

- Injected SF_6 and Ar
- No Ar detected, as expected from lab
- Looked for wider spectrum of SF_6 ions
- Detected tiny returns of SF_6 at 2.25hr, near CO_2 / RA peak times
- **Match, detection level = < 1ppm SF_6!**
- 10,000x less tracer volume than CO_2



Next Steps

RA Tracing

- Effective, non-intrusive, and available!
- Tracing economics highly dependent on RA isotope
- Kr-85 (10yr half-life) is preferred and ~1/10th cost of Kr-79, but was unavailable—new supplier identification in progress

SF_6 Tracing

- WH-internal sampler was an improvement over typical tracer setup
- Plan to repeat test with dip tube bottle
- A SF_6 specific measurement device could be even better
- May lead to automated GL tracing in the future…

Questions?

References

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2. *Global GL Optimization Using WellTracer® Surveys* – **2013 ALRDC GL Workshop**, ExxonMobil
3. *Performance of Hawkins Field Unit Under Gas Drive-Pressure Maintenance Operations and Development of an Enhanced Oil Recovery Project* – **SPE/DOE-17324-MS**, Exxon Co. USA (1988)
4. *Performance and Expansion Plans for the Double-Displacement Process in the Hawkins Field Unit* – **SPE-28603-PA**, Exxon Co. USA (1995)
5. *Reservoir Simulation of Gas Injection Processes* – **SPE-81459-MS**, ExxonMobil Upstream Research Co. and ExxonMobil Production Co. (2003)

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