RESMAN®

GAS TRACER SYSTEMS

AN INTRODUCTION

SPE-225562-MS

Zonal Quantification of Gas and Condensate from Tracer Systems and Wellbore Simulation

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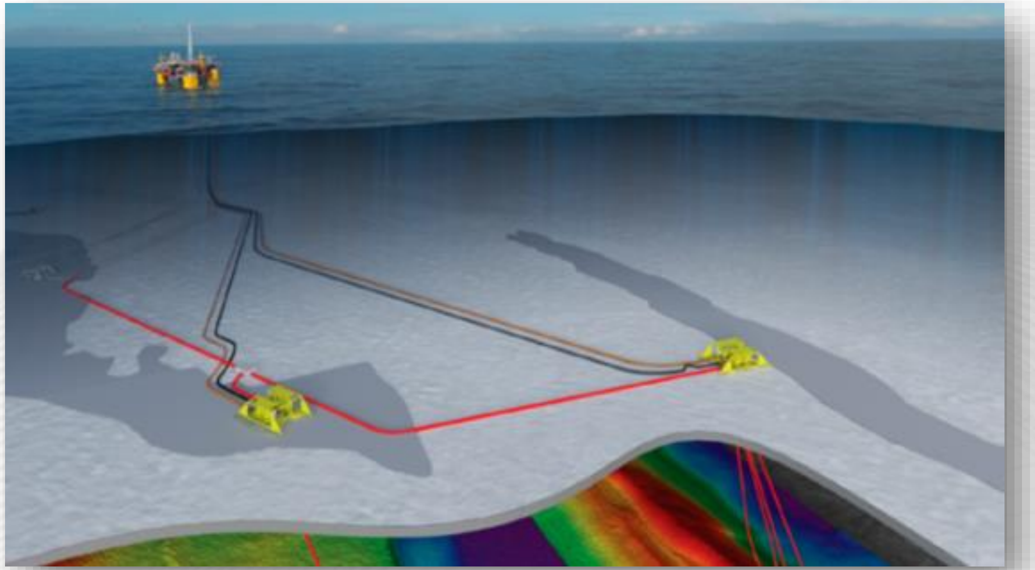
AGENDA

- Background
- Gas Tracers Development
- Methodology
- Well case study
- Inflow quantification from tracer systems
- Tracer vs Simulation results
- Discussion
- Conclusions

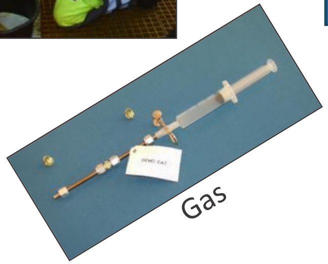
BACKGROUND

- Field development in the Norwegian Sea with high reservoir uncertainty /connectivity
- Long wells for maximizing reservoir exposure
- Step-wise field development to learn from first wells
- → Information from tracer system as input to the «reservoir puzzle»
- **Challenges**
  - Gas tracer development needed
  - Reservoir conditions:
    - high temperature (170°C)
    - medium pressure (518 bar)
  - Commingled flow – higher number of unique tracers



PRODUCTION SYSTEMS – HIGH LEVEL WORKFLOW

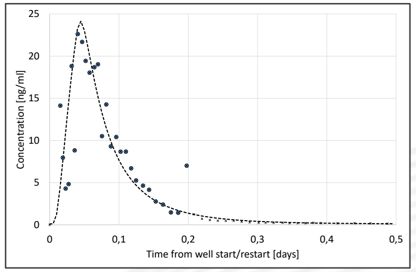
3 **Sampling**

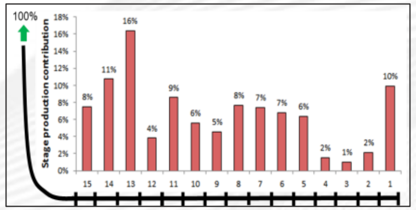


Oil/water

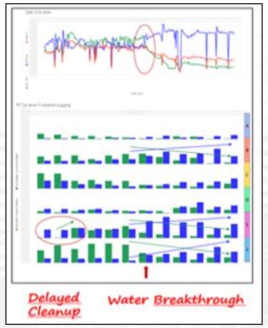
4 **Analysis**
(parts per trillion)

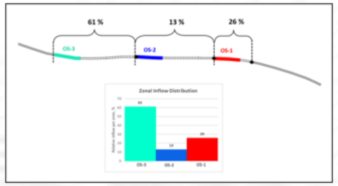
5 **Interpretation**

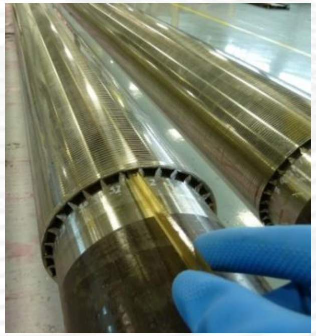


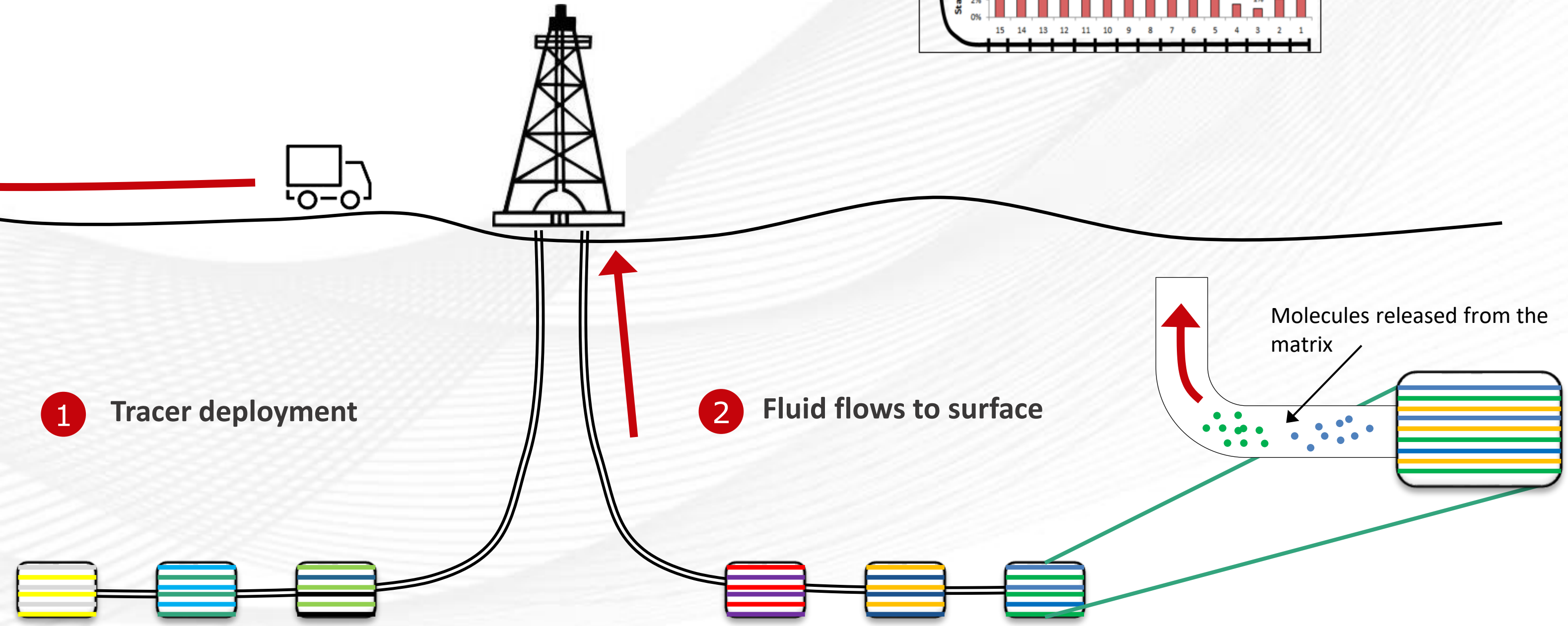


6 **Deliverables**









1 **Tracer deployment**

2 **Fluid flows to surface**

Molecules released from the matrix

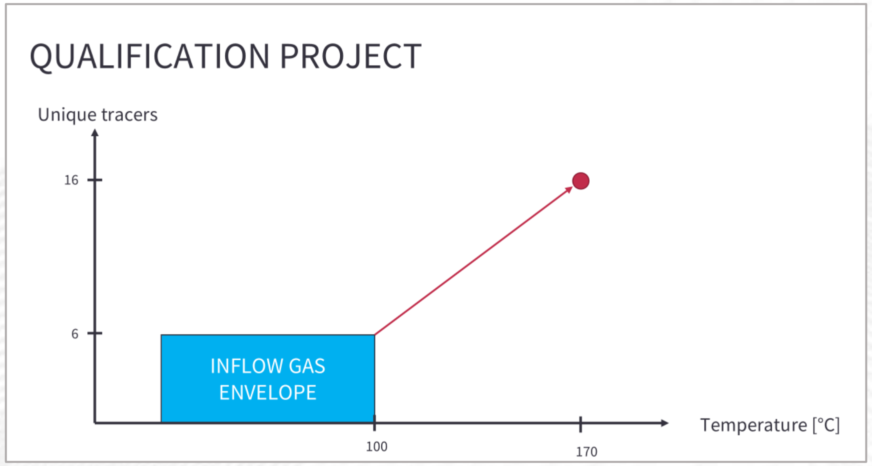
Molecules for water detection
RES•H2O

Molecules for oil detection
RES•Oil

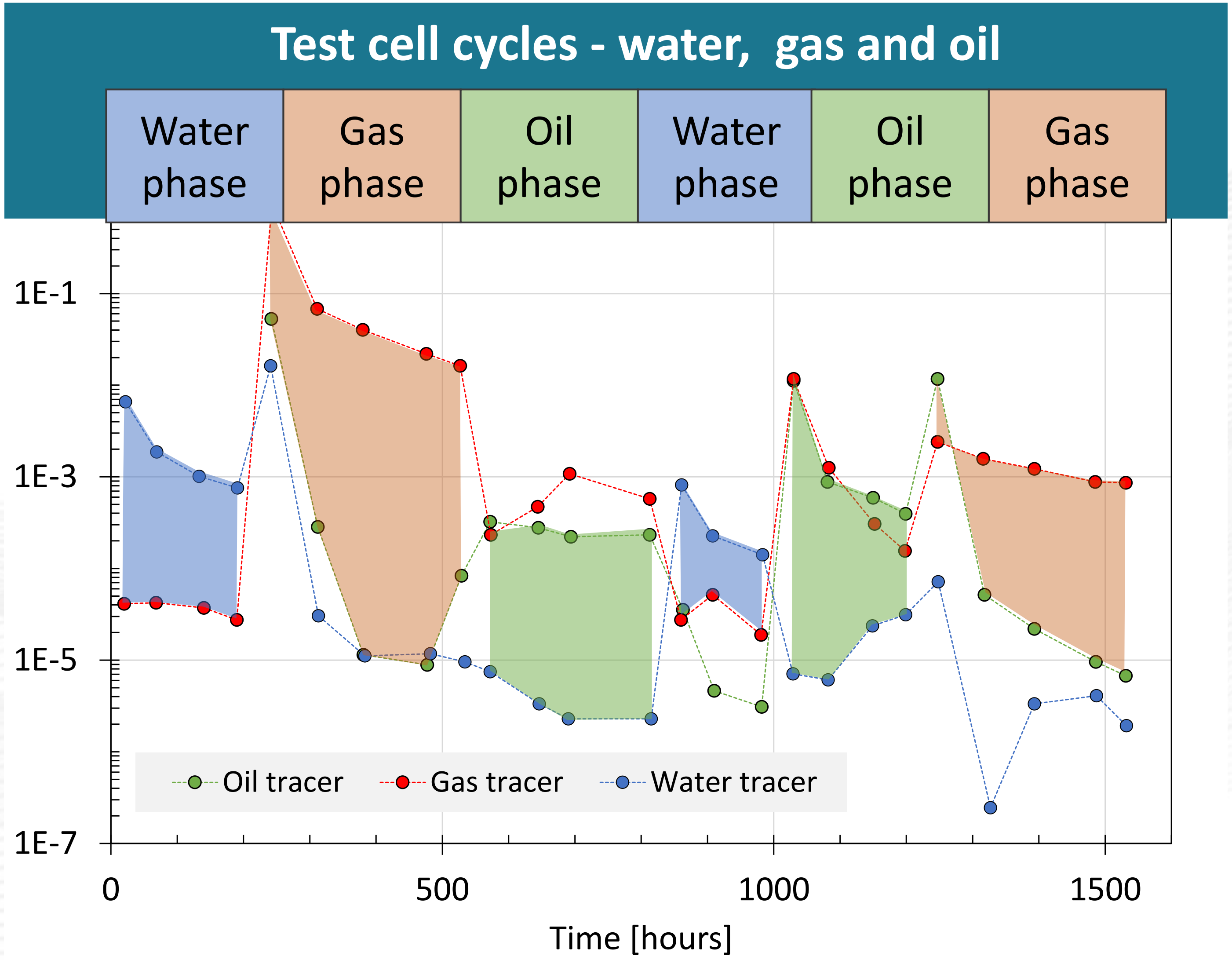
Molecules for gas detection
RES•Gas

GAS TRACERS DEVELOPMENT

- ***Gas tracer technology*** relatively novel compared to oil and water tracer systems. Adaptation to field conditions based on laboratory work.
- ***Tracer qualification program*** for development of gas tracer systems for high temperature (170°C) and medium pressure (518 bar).
- ***Tracer longevity up to one year*** at a planned gas flow rate.
- In total ***17 individual systems*** qualified for this development.

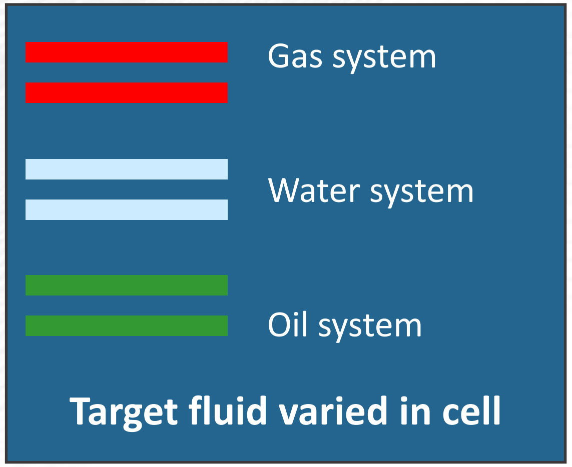


VERIFICATION OF RES•GAS FUNDAMENTALS



Results

- Gas tracer releases primarily to gas
- Oil tracer releases to oil
- Water tracer releases to water



NO PRESSURIZED GAS / OIL SAMPLES

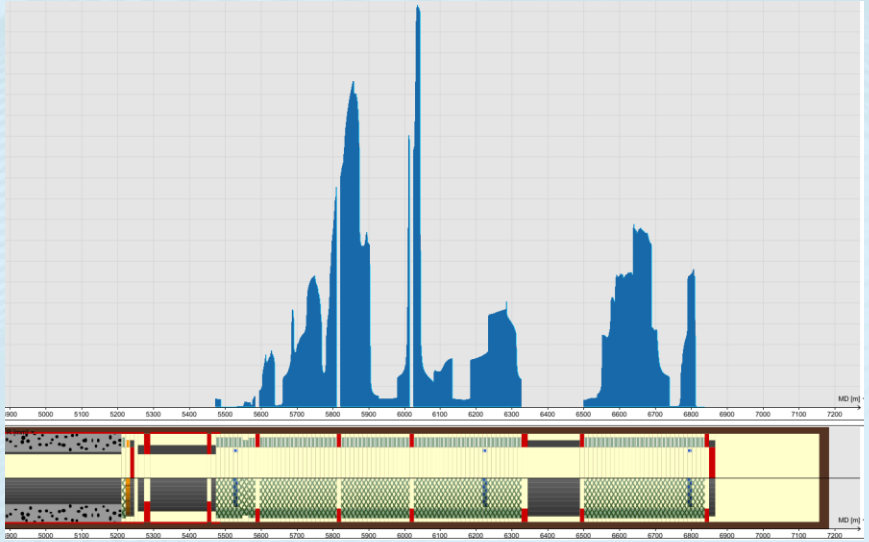
- Eliminating the need for high pressure cylinders for sampling
- Easy sampling by field personnel

- Logistics:
  - Small sample size
  - Rapid shipment
  - No MSDS required
  - Non-dangerous goods
  - No flammable gas in sample, not pressurized

METHODOLOGY, FIELD CASE (SPE 225562)

- Polymer-based tracer systems and relevant methods to assess wellbore flow

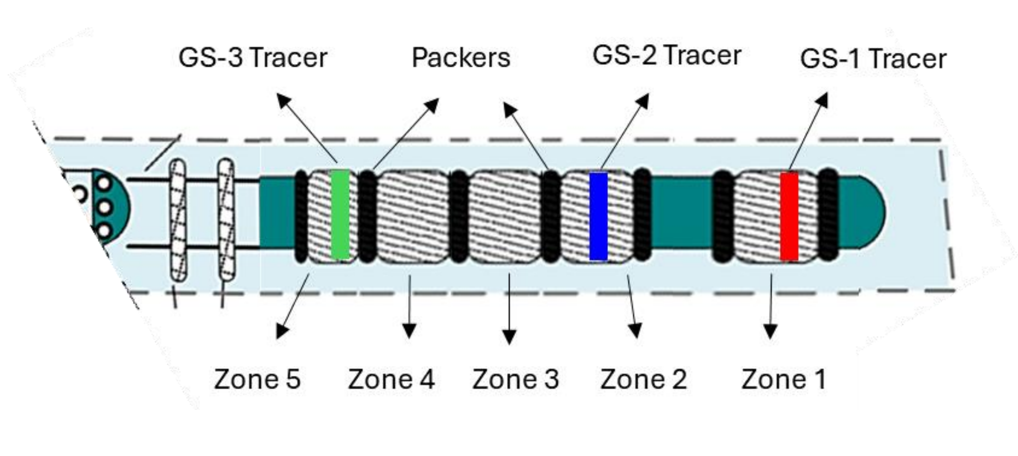
- Wellbore simulation of gas inflow rate (Halliburton, 2024)



WELL CASE STUDY, FIELD CASE (SPE 225562)

- Well completed with sand screens and swell packers for sand control
- Tracer rods mounted on selected sand screens
- Tracer data combined with simulation studies to provide ***inflow gas rate*** across the horizontal section.

Well Completion



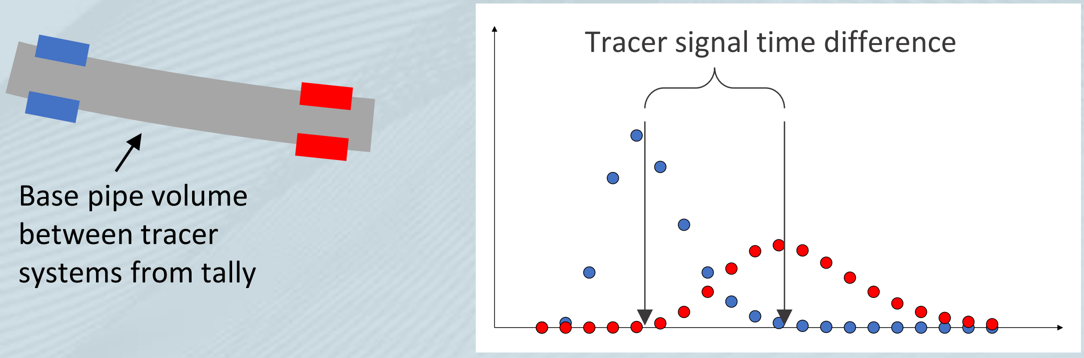
- Well completed with sands screens
- **Five gas-producing zones** across the well length.
- Three zones monitored by **unique tracers.**

QUANTIFY INFLOW FROM TRACER SYSTEMS

- Install systems with completions
- Accumulate tracer mass at tracer system installation during natural or induced production stop
- Restart well and sample frequently to capture tracer signal
- Characterize and model tracer flow in the well and extract inflow rate from tracer signal

Inflow rate assessment from Tracer systems

(Arrival Time Method)



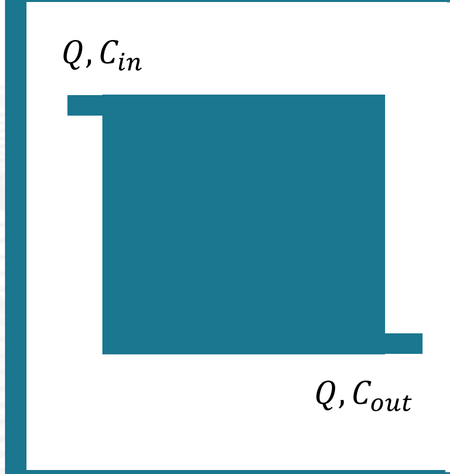
Rate = Volume / Time difference

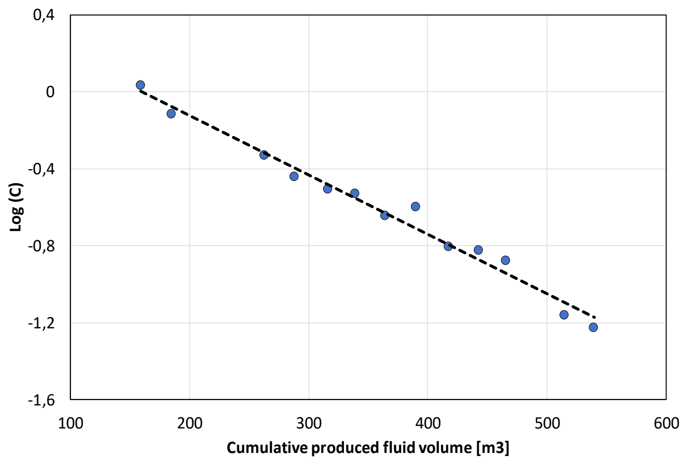
CAMPAIGN-BASED TRANSIENT FLOW INFORMATION FROM TRACERS

"Flush-out" method:

- Accumulate mass in a confined space (e.g. annular volume, sand screen etc)
- Characterize the decline of accumulated tracer mass
- By solving the mass conservation equation we have

$$\partial c(t)/\partial t = -Q \cdot V \cdot c(t)$$

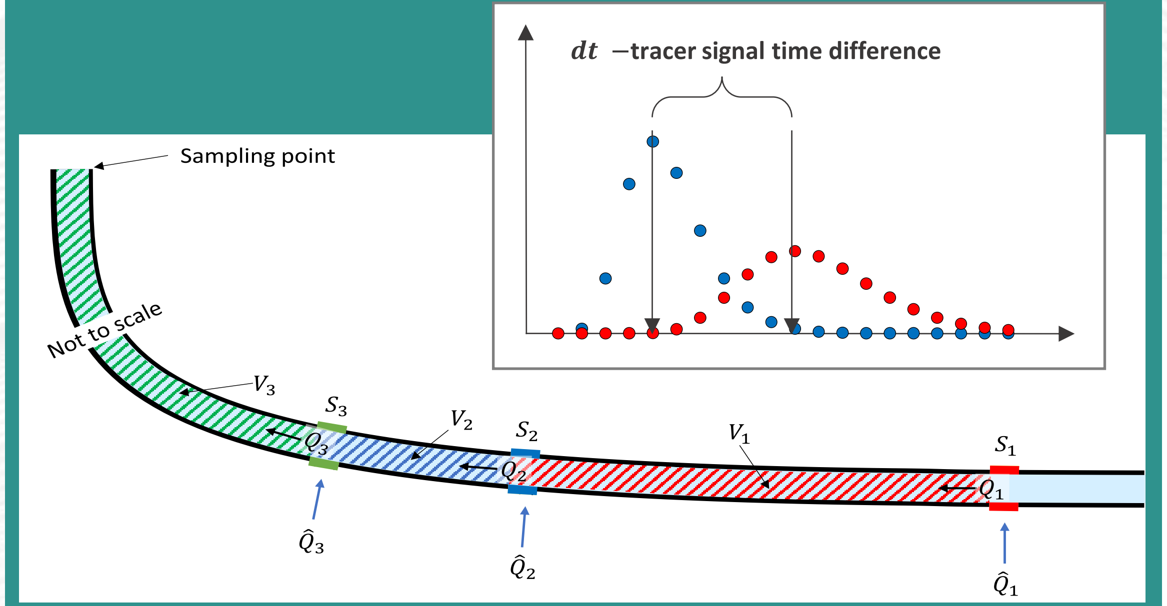




"Arrival time method" method:

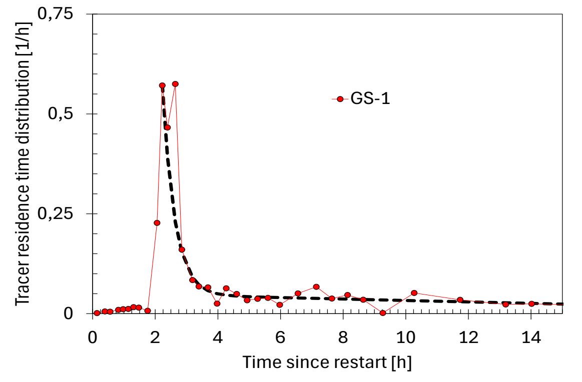
- Accumulate mass in a confined space (e.g. annular volume, sand screen etc)
- Use base pipe volume and time difference of arrival of clouds

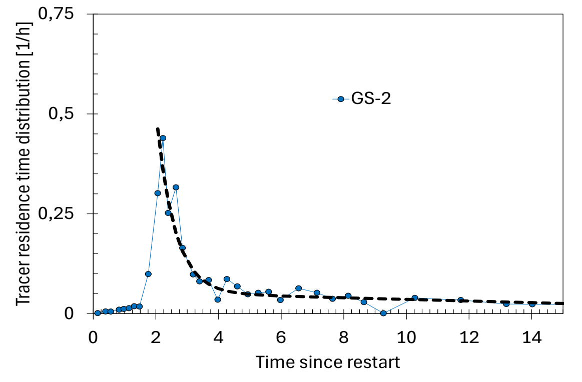
$$Q = V/\Delta t$$

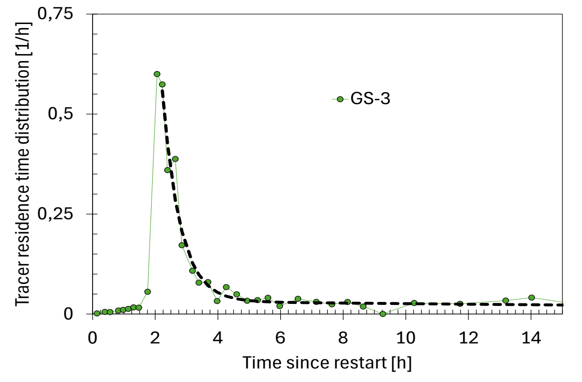


TRACER INTERPRETATION RESULTS

«Flush Out» Method

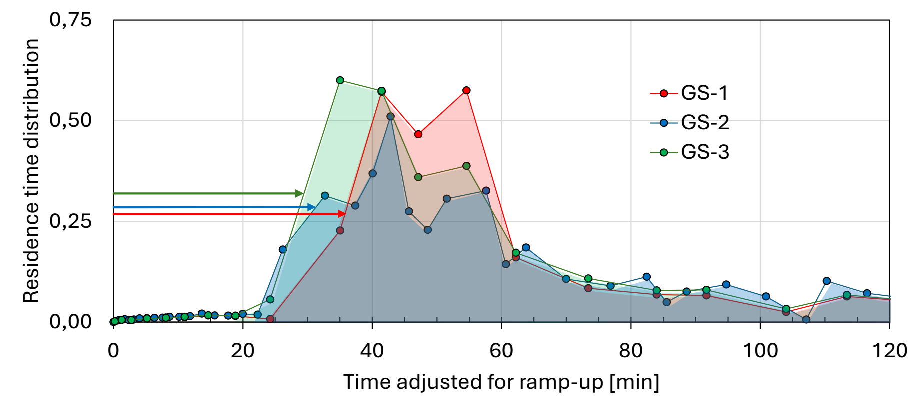






Item	GS-3	GS-2	GS-1
Decline parameter κ	1.7	1.7	2.5
Zonal length [m]	123	300	335
Zonal contribution	**13%**	**33%**	**54%**

«Arrival Time» Method



Item	GS-3	GS-2	GS-1
Arrival time [min]	29.4	32.7	37.4
Rate contribution	886	2230	3094
Zonal contribution	14 %	36 %	50 %

TRACER VS SIMULATION RESULTS

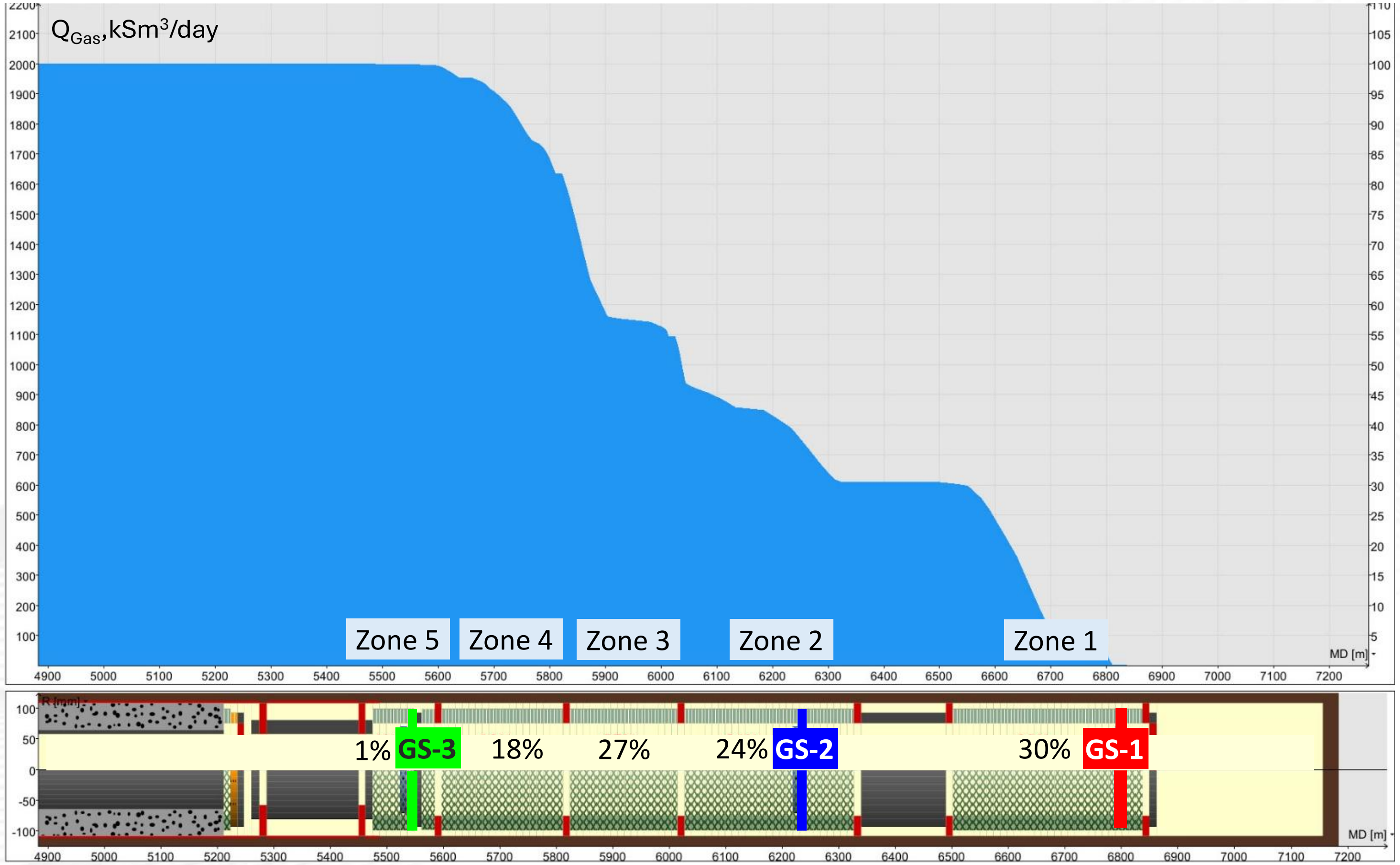
Modelling

Item	Zone 5, GS-3	Zone 4 No tracer	Zone 3 No tracer	Zone 2, GS-2	Zone 1, GS-1
Share, total flow	1%	18%	27%	24%	30%
Share, normalized tracer zones	**2%**	-	-	**44%**	**55%**

Tracer data

Item	Zone 5, GS-3	-	-	Zone 2, GS-2	Zone 1, GS-1
Zonal contribution from Tracers, %	**13%**	-	-	**33%**	**54%**

Gas – Cumulative Flowrate (Bottom to Top)



DISCUSSION

Tracer systems as alternative to PLT?

- Wellbores inaccessible to wireline operations
- Tracers do not disturb the flow

Method uncertainty

- Relative uncertainty due to (long) transportational time vs difference in arrival time
- Resolution of well inflow rate depends on number of systems (3 systems vs 5 zones)

Mutual confirmation of methods

- Two tracer interpretation techniques (Arrival time and “Flush-out”) mutually confirms each other
- Wellbore simulation and tracer mutually confirms each other

CONCLUDING REMARKS

- Gas tracer in **high temperature** and **medium pressure** environment achieved by collaborative effort between service provider and operating company.
- **Gas tracer systems and well modelling confirmed flow** from all parts of the well, with a significant production from the toe.
- Repeated restart campaigns are useful to **monitor well's behavior over time**, in addition to increased tracer lifetimes.
- Upcoming tracer systems installed in other wells in the field may offer **new insights** for quantifying flowrate in challenging environments.

THANK YOU / QUESTIONS