The World Leader in Polymer Technology
For Enhanced Oil Recovery

Injection of polymer solution From surface to wellbore

Mechanical and Chemical degradation

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30th May, 2011

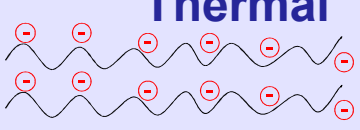
Introduction

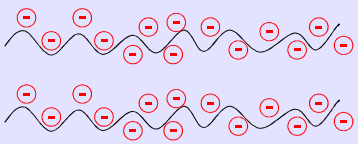
- What are the possible degradations and the way to minimize them
- Chemical degradation : problem of Oxygen in presence of Fe 2+ or H2S
- Mechanical degradation :
  - Where : pump, ICD , perforation
  - How to minimize them

Possible degradations

Factors influencing polymer solution viscosity

Thermal



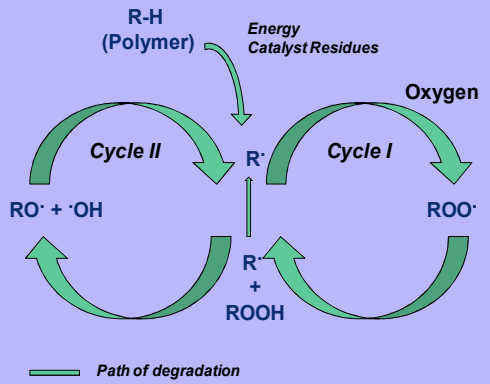


Why : high Temp., pH

Problems : more sensitive to Ca, Mg - viscosity drop, precipitation

Solution : adapt chemistry of polymers, water treatment (softening, anti scaling)

Chemical

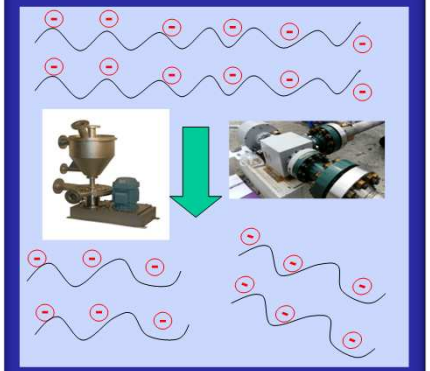


Why : Redox system, $FE^{II}/O2$, H_2S/O_2, weak links in the polymer, impurities

Problems : drastic Mw and viscosity drop

Solution : adapt chemistry and production process of polymers, use appropriate protective additives, remove contaminents (H_2S, O_2, iron)

Mechanical

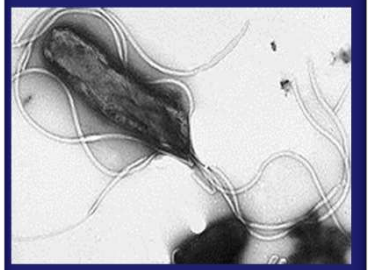


Why : mixing, transfers through pumps and gates, perforations

Problems : Mw and viscosity drop

Solution : PSU, Use of lower Mw

Biological



Why : Presence of Bacteria (SRB..)

Problems : Mw and viscosity drop

Solution : Use of biocides compatible with polymer and with deoxygenating system

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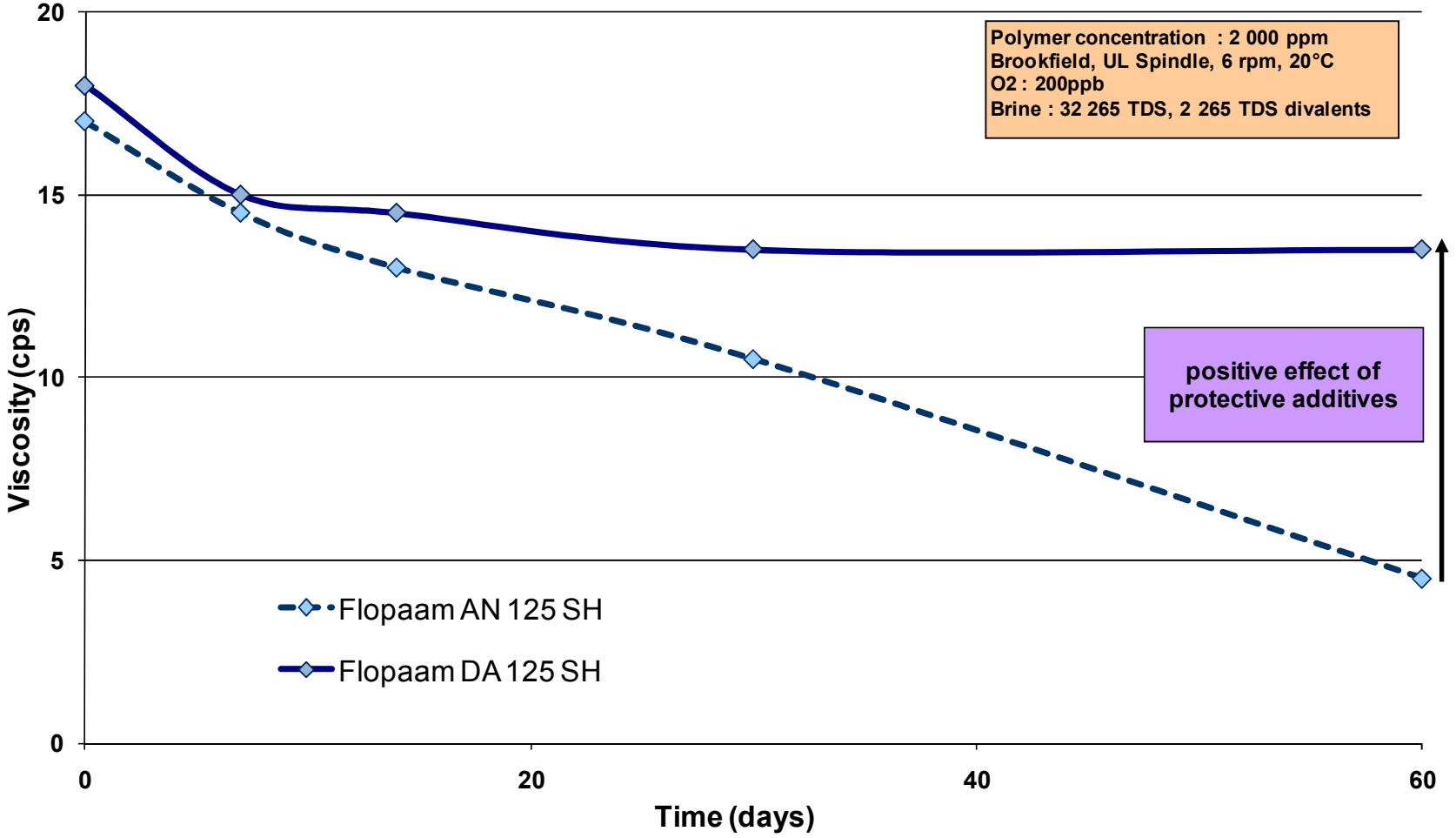
Impact of presence of oxygen : efficiency of F3P

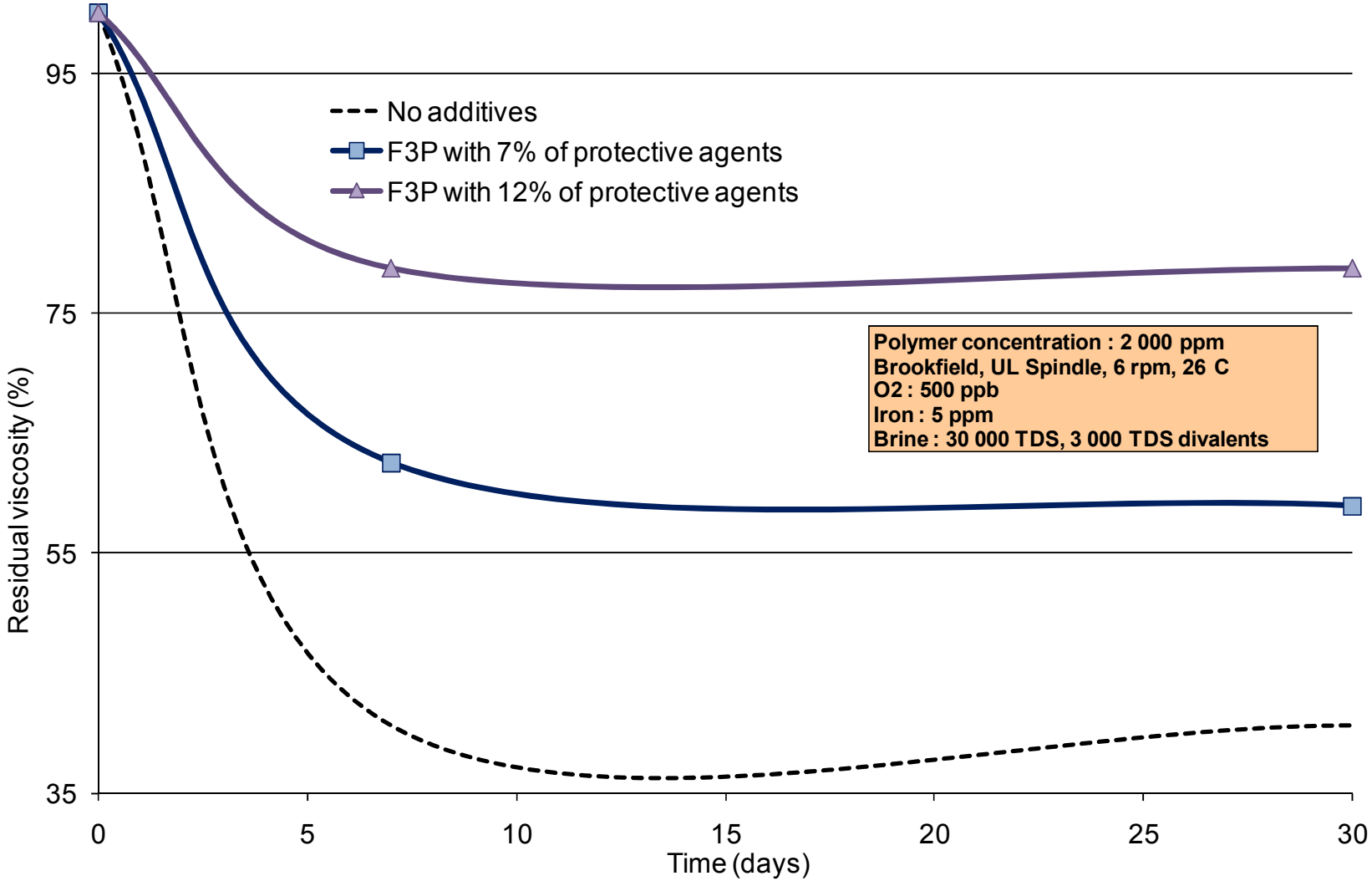
Evolution of viscosity of Flopaam™ AN 125 SH (ATBS/AMD copolymer) and corresponding F3P @ 100°C in presence of divalent cations



Contribution of hydrolysis to viscosity is lower than chemical degradation

The medium term effect of Fe II and O_2 : 30 days

80°C - poly(acrylamide-co-acrylic acid) Flopaam 3630S type 500 ppb O2, 5 ppm Iron II, synthetic sea water



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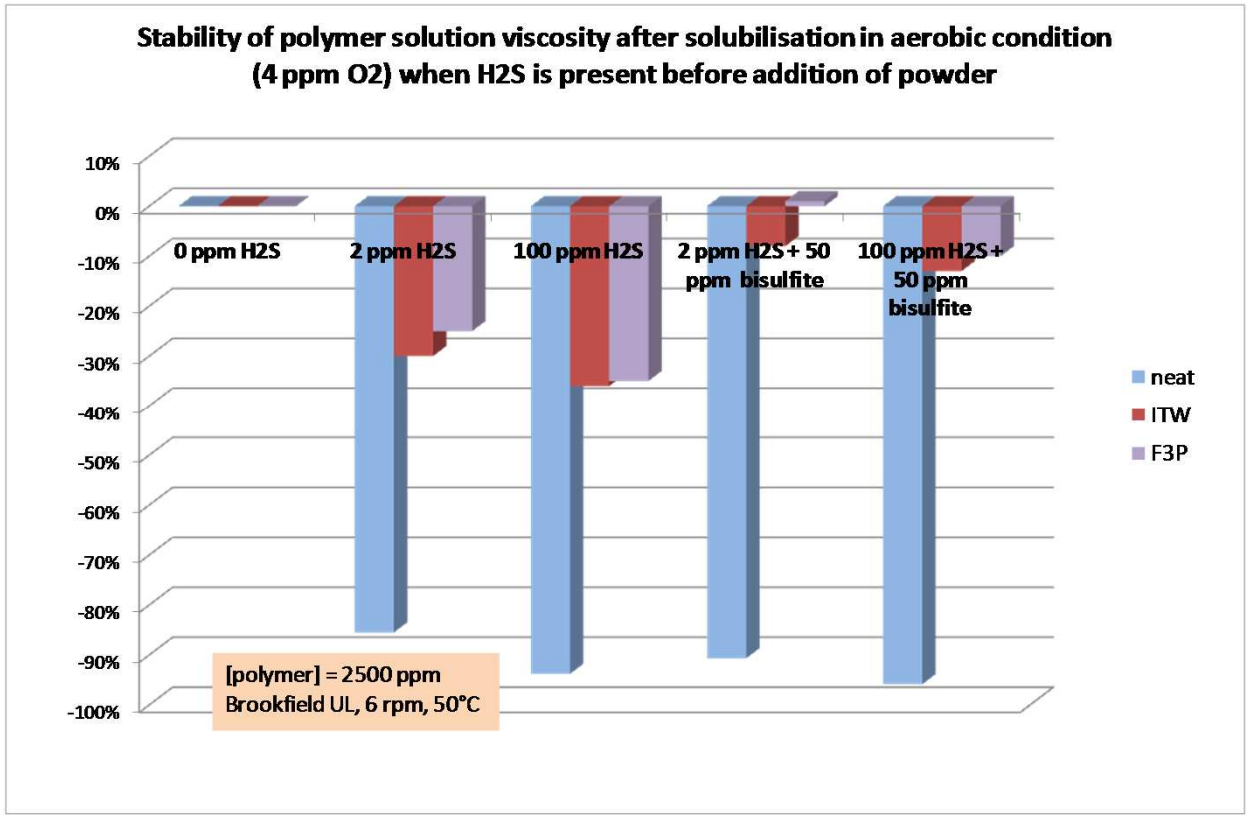
The immediate effect of H_2S and O_2

Impact of O2 and H2S

no nitrogen blanketing,
4 ppm of O2 coming in the line
H_2S : 2 ppm and 100 ppm

dissolution of the powder in a vessel under air atmosphere in presence of H2S



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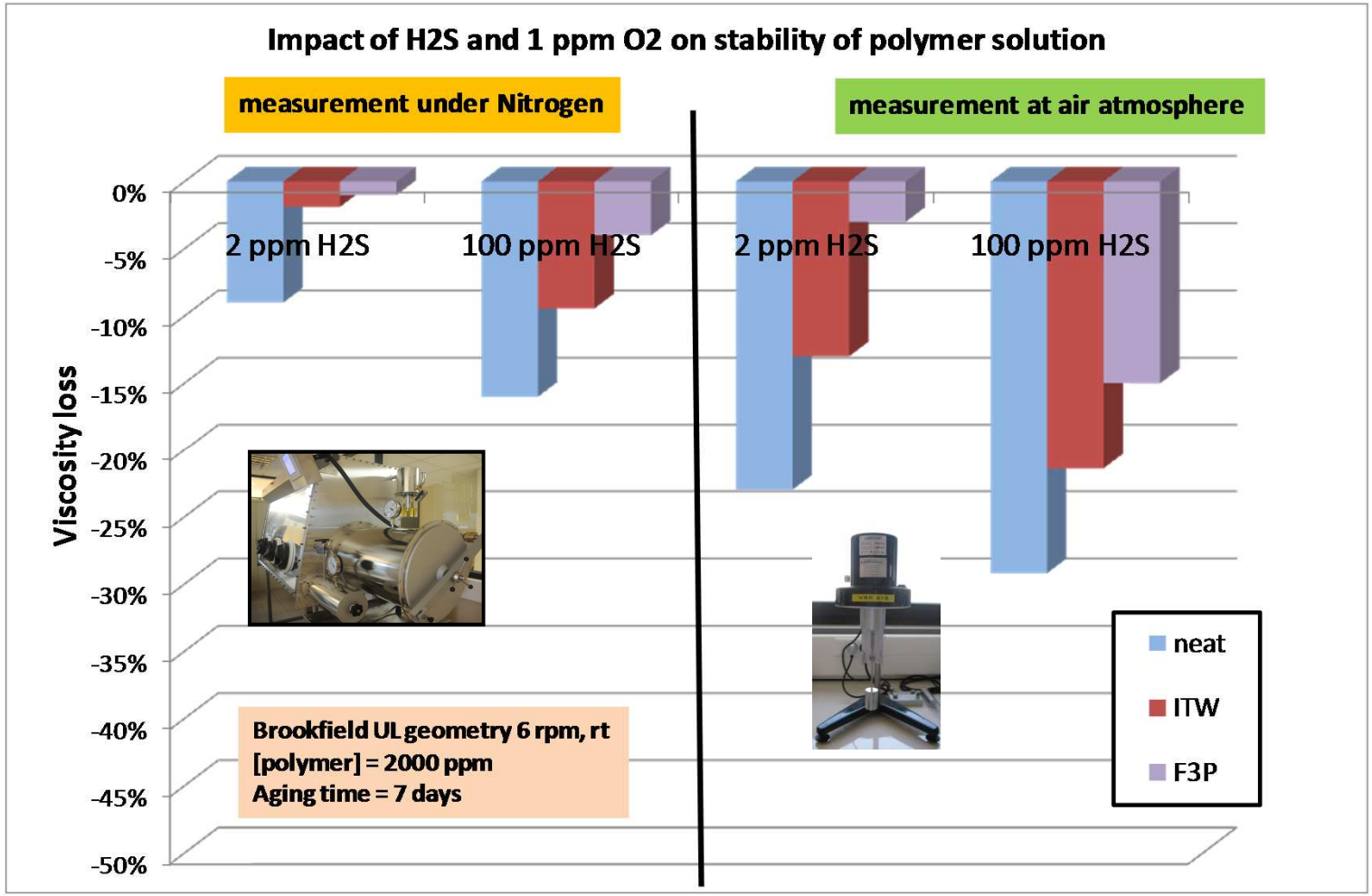
The medium term effect of H_2S and O_2

Aging results : **1 ppm of O_2**
H_2S : 2 ppm and 100 ppm



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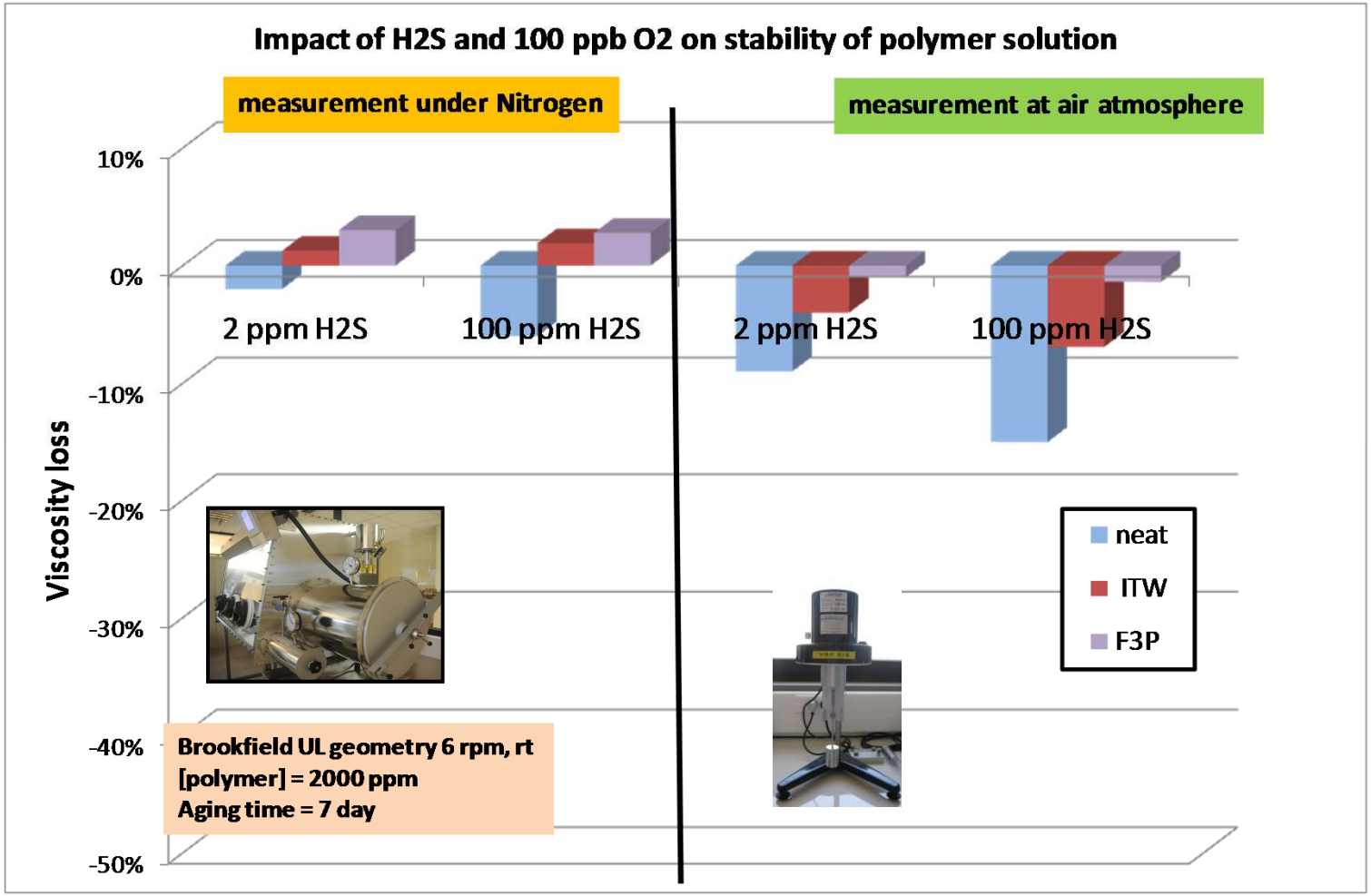
Medium term effect of H_2S and O_2 (2)

Aging results : Low amount of O2 : **100 ppb of O_2**
H_2S : 2 ppm and 100 ppm



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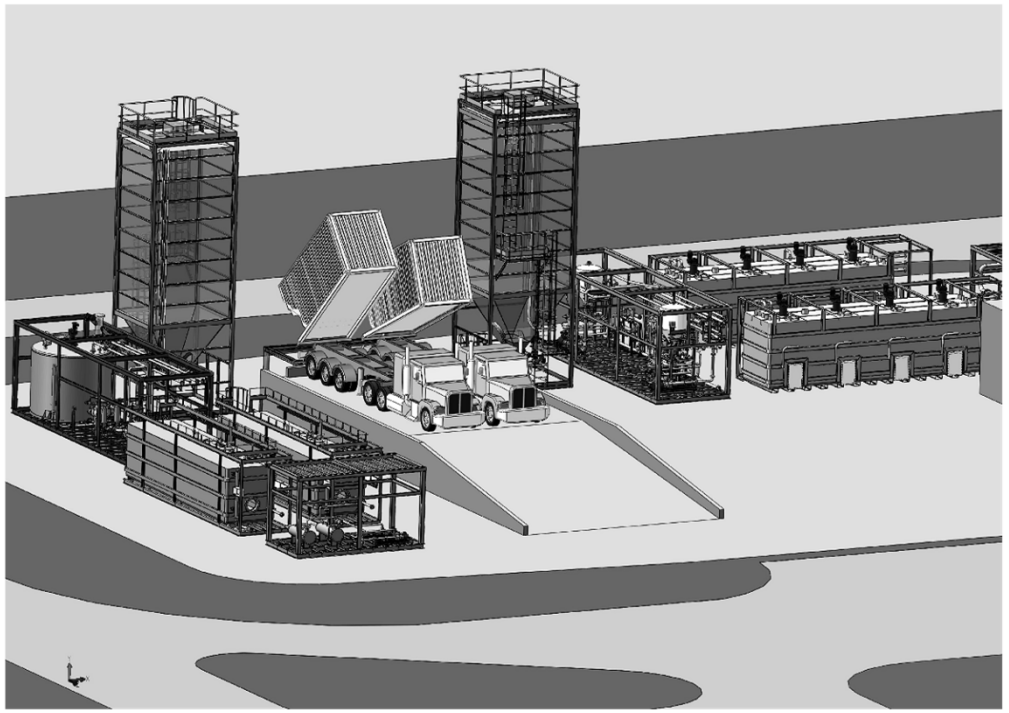
ITW vs. F3P

→ **ITW (Mixture of isopropanol 15% / Thiourea 7.5% and water 77.5%)**

→**Require storage, dosage and separate injection each component**

ITW : HSE issues
- Harmful
- Flammability
- Environment (spills, odor, etc)



ITW is efficient but induces limitations to be implemented in every EOR projects

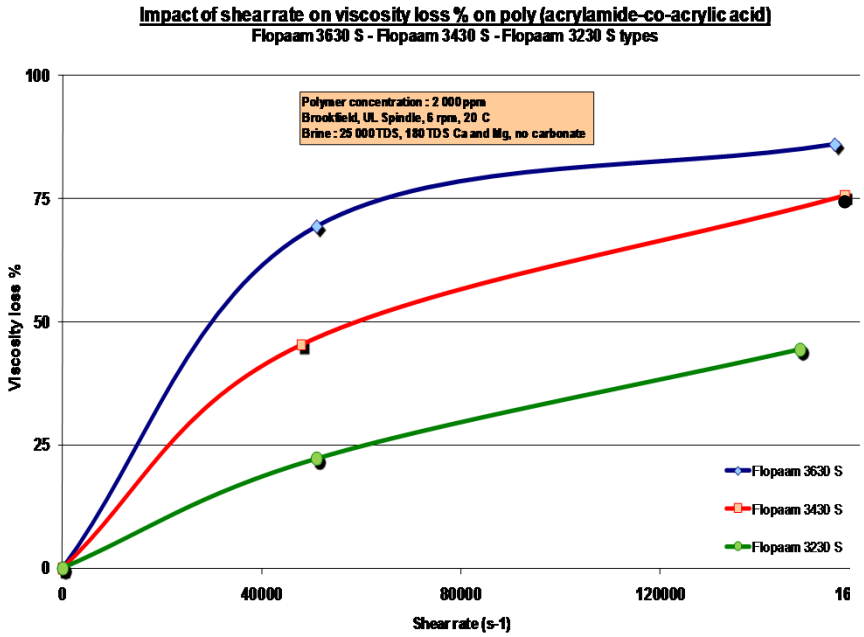
F3P are ECONOMICAL
- Price of additives
- No limitationsNumber of additives
- No additionnal supply chain
- No additionnal Handling & Storage
- No additionnal Injection facilities

	FP3630S + ITW	F3P
Labeling polymer	none	none
Labeling IPA	Xi, F, R36, R67, Fp = 12°C	
Labeling thiourea	Xn, R40, R63, R51/53	

Mechanical degradation

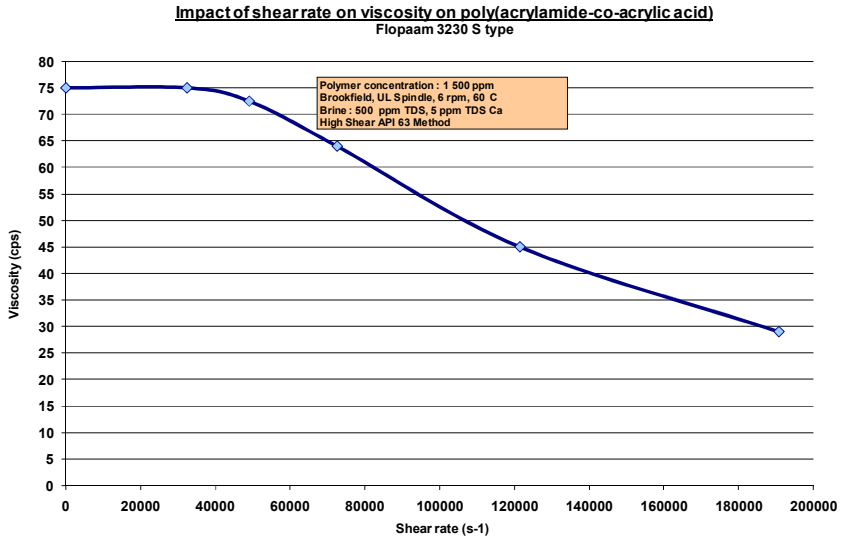
- Where :
  - Pumps
  - Choke , Manifold
  - Completion : ICD
  - Perforations

Influence of shear rate in function of MW



The lower is the molecular weight , the lower the degradation is.

The optimum MW is maybe not the highest one in term of recovery and economics.



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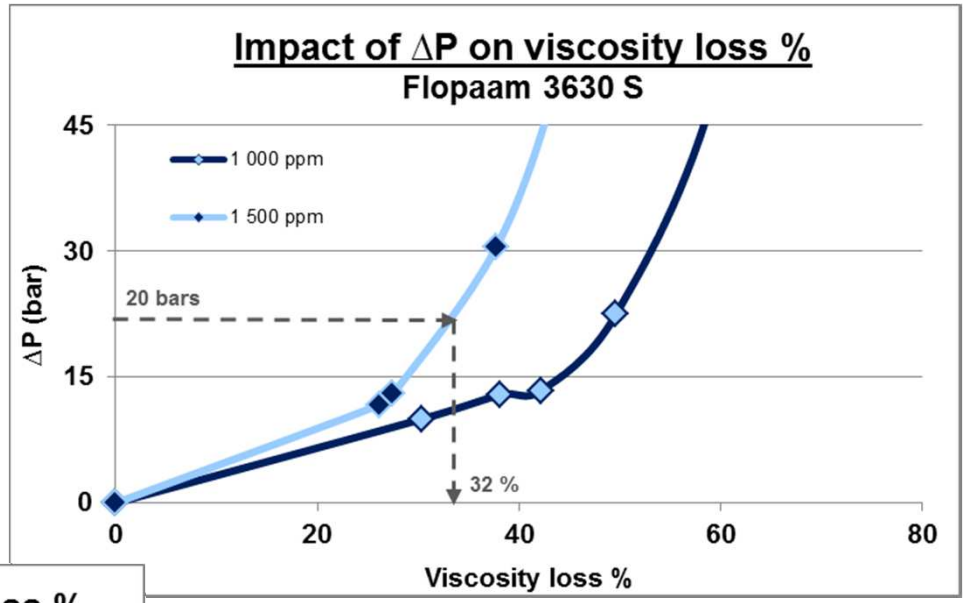
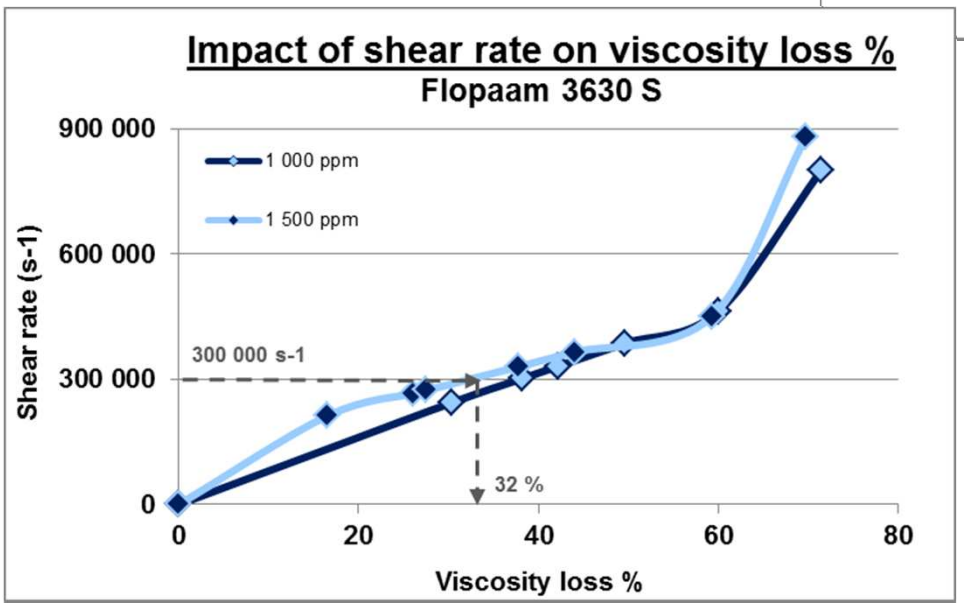
Pumps

- Centrifugal pumps cannot be used for polymer solutions
- Overall degradation of the solution going through the pump and the choke is directly linked to the pressure drop applied to the solutions
- Triplex pump is leading to almost no degradation.
- PCP pumps need to be carefully selected :
    - Degradation is limited (less than 10%) if the correct rotor is used
    - This is due to internal leakage of the solution in the chambers of the pump
    - Internal leakage is specific to each solution and is linked to the discharge pressure drop

Chokes

Impact of pressure drop on viscosity is very important





A 300,000 s-1 shear rate leads to a 32% viscosity reduction.

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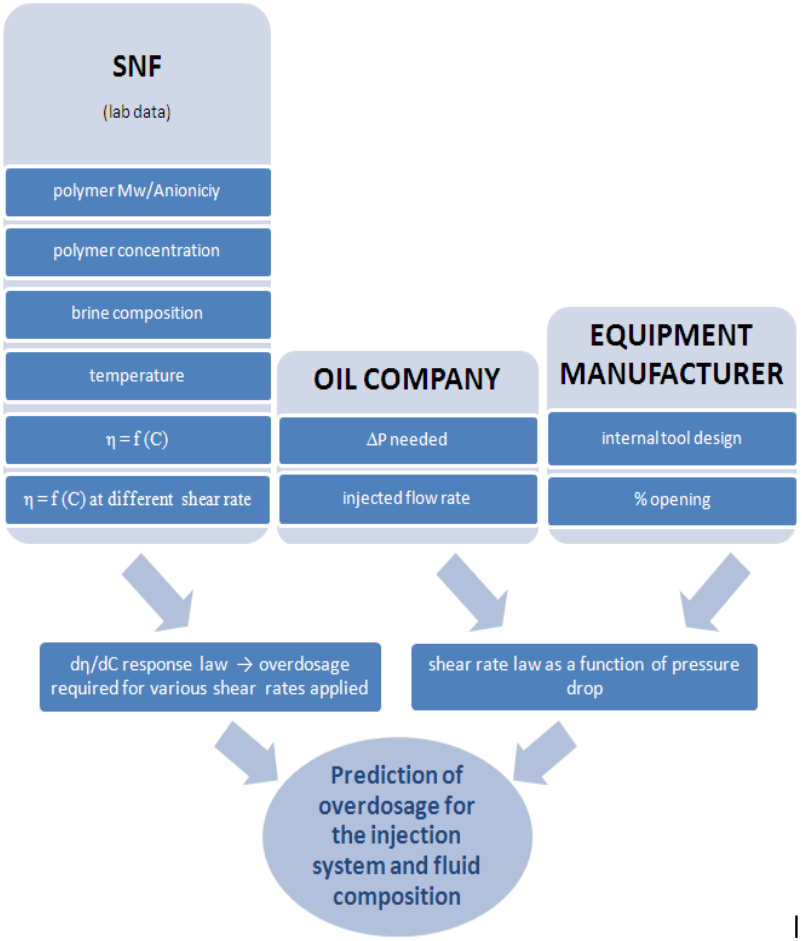
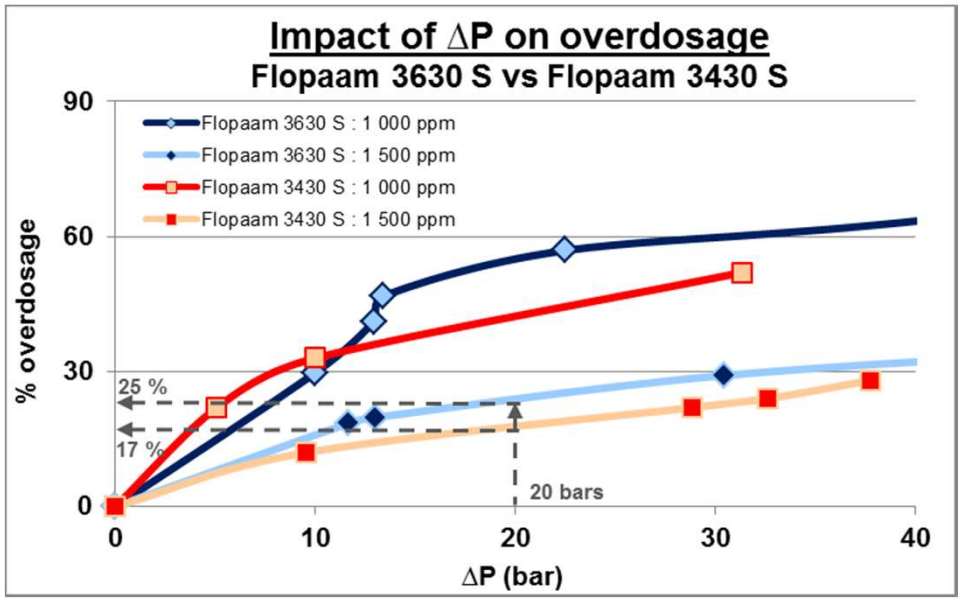
Chokes : Overdosage



Typical data generated with 2 polymers at 2 concentrations, for a given choke design and opening

This choke required a 15 to 60% overdosage depending on the pressure drop. The over dosage is reduced for lower MW.



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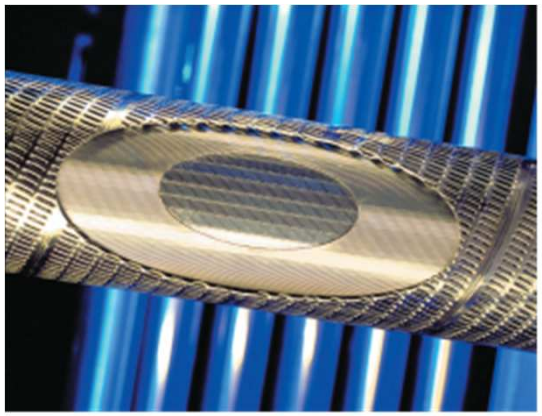
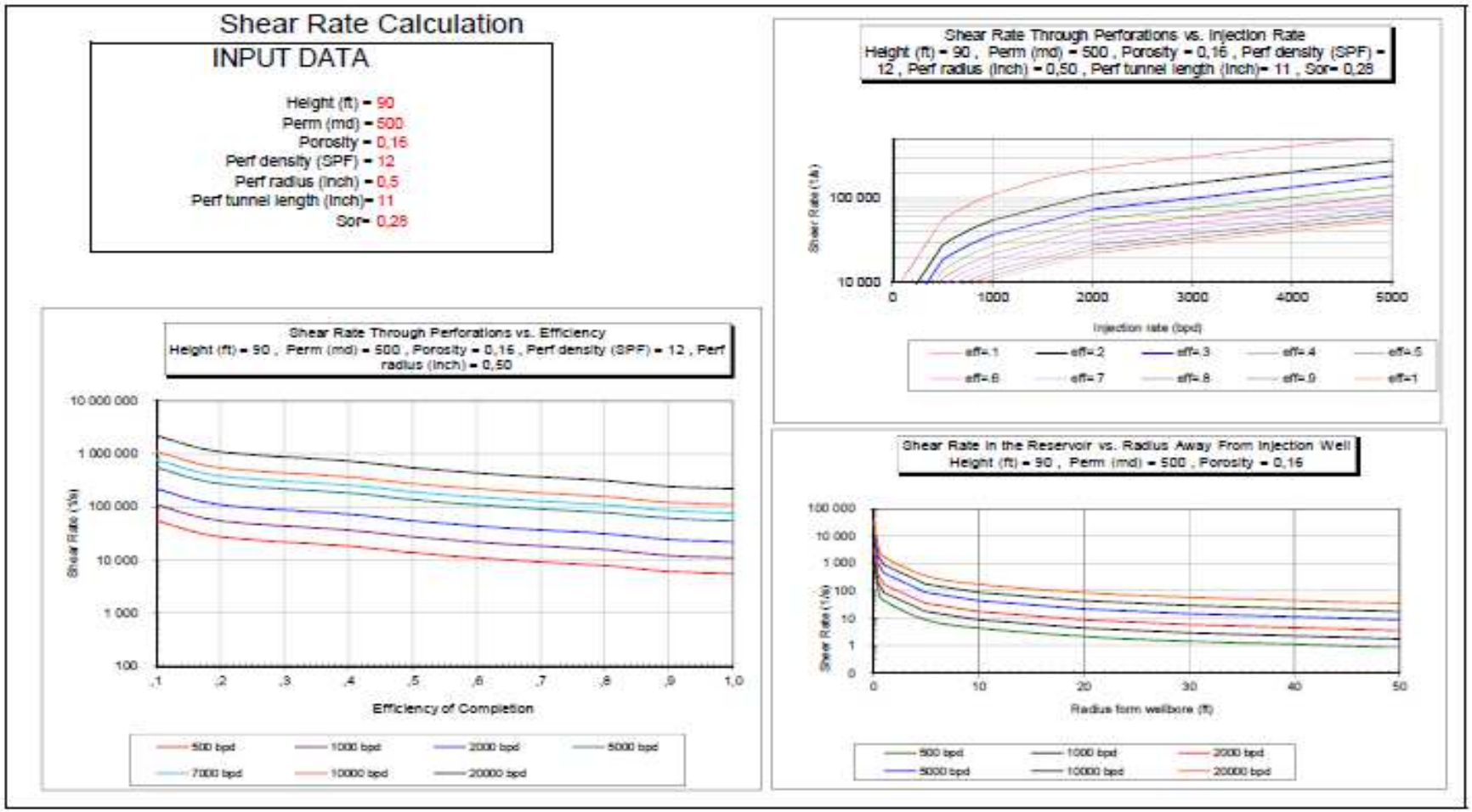
ICD and screen liner

- **An ICD implementation must take into account parameters such as number of nozzle, size of nozzle, flow rate, but is manageable to minimize degradation**
- **Wire wrap liner**
- Tests performed indicated no degradation through this completion liner.
  Even if flowrate was 35 times the one expected, the degradation was less than 10%



Perforations

Optimisation of the perforation : use high density shots per meter (20 to 40)



Conclusions

- Chemical degradation and mechanical degradation can be largely minimized
  - Mechanical degradation does not add up
- Choke remains the biggest problem , and if possible should be placed before the introduction of polyme solution
- Surface equipments needs to be design according guidelines such as :

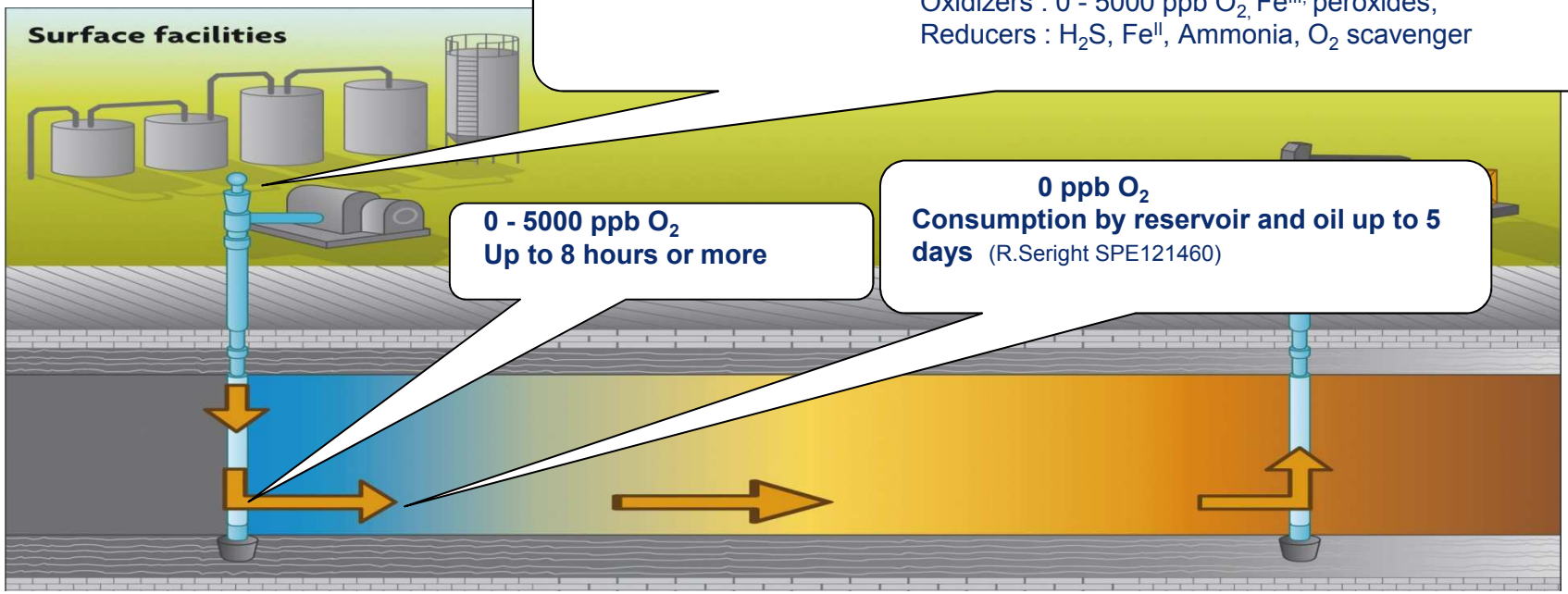
  - Piping : Maximum speed of 2 m/s
  - Agitator : Maximum speed of impellers of 1.5 m/s
  - Triplex pumps : Maximum speed of non-return valves of 3 m/s
  - Choke :Limited diameter pipe before the choke ; Choke with one orifice only
  - Low shear valves

What is the real viscosity in the reservoir ?

Surface facilities : The dilution water of the polymer solution is very often produced-water containing several chemicals, some of them in minor amount:

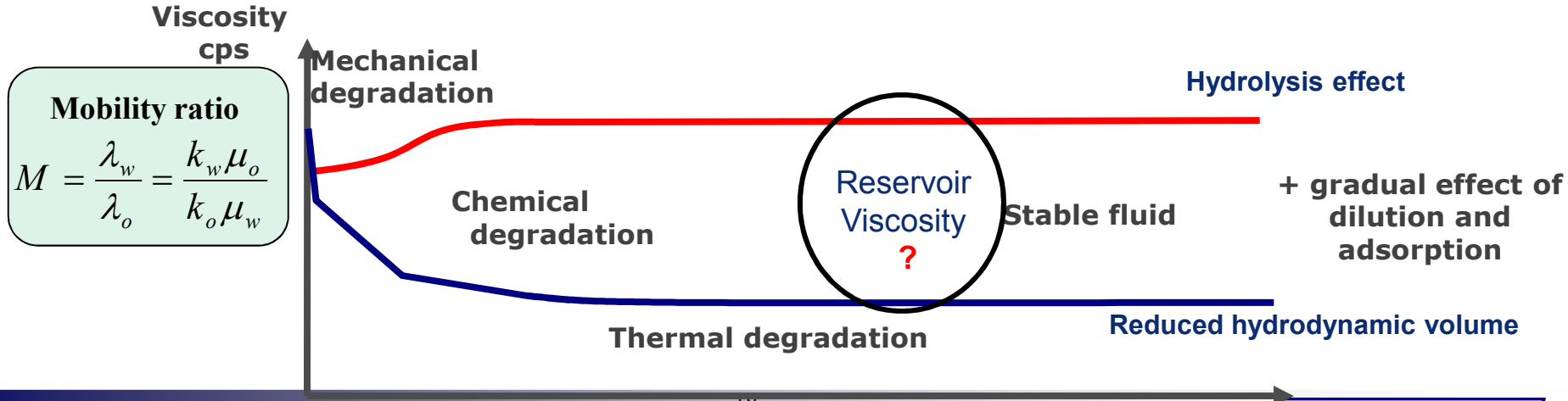
Oxidizers : 0 - 5000 ppb O_2, Fe^{III}, peroxides,

Reducers : H_2S, Fe^{II}, Ammonia, O_2 scavenger



Mobility ratio

$$M = \frac{\lambda_w}{\lambda_o} = \frac{k_w \mu_o}{k_o \mu_w}$$



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Thank you