Bacterial Control in Oilfield Systems

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COQG
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Bacteria

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1,000 X

10,000 X
Location of Bacteria

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Scale & Solids
Slime
Bacteria
Bacteria Require Water

Pipe

Gas

Condensate

Water

Planktonic Bacteria

Sessile Bacteria Colony

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Sessile Bacteria

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Bacteria Related Oilfield Problems

- Biogenic Sourcing (H$_2$S)
- Microbiologically Influenced Corrosion (MIC)
- Plugging
- Emulsion problems
Sulfate Reducing Bacteria

Sulfate → SRB → H$_2$S

Carbon

Alcohols,
Organic Acids
Biogenic Souring

Hydrogen Sulfide Concentration in Sturgeon B3HI Production Well

- Hydrogen Sulfide (ppm): 0 to 70

Graph showing the increase in hydrogen sulfide concentration from 1992 to 2000.
MIC - SRB Pitting

Pipe As Received

Cleaned Pipe

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MIC – APB Pitting

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Biomass Plugging
Iron Sulfide Plugging

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Emulsions

- Bacterial slime and iron sulfide accumulate at oil-water interface
  - → pads in tanks
  - → emulsions

- Bacterial slime and iron sulfide become coated with oil (oil-wet) and fall into water layer
  - → oil carryover
Avoid build-up of solids

Eliminate stagnant areas

Remove solids from system

Pig flowlines

Avoid Mixing waters
Effective treatment requires CONTACT TIME and CONCENTRATION.

Periodic Treatments Are Necessary
- Bacterial survivors re-establish
High Throughput Biocides

- water-soluble
- non-foaming
- good system throughput
- reservoir compatible

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TetrakisHydroxymethyl Phosphonium Sulfate

\[
\text{HOCH}_2\text{PCH}_2\text{OH} \quad \text{SO}_4
\]

\[
\text{HOCH}_2\text{PCH}_2\text{CH}_2\text{OH} \quad \text{SO}_4
\]

GLUTARALDEHYDE

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Filming Biocides

- excellent cleaner
- penetrate biofilms
- can cause foaming
- filming can limit system throughput

**QUATERNARY AMINE**

\[ \text{H}_2\text{N-CH}_2\text{CH}_2\text{CH}_2\text{-N} \]

\[ \text{COCODIAMINE} \]

\[ R = \text{coconut oil} \]
Acrolein

- Penetrates oily films
- non-foaming
- good system throughput
- reservoir compatible
- scavenges H₂S
Acrolein Degradation

Acrolein $\rightarrow$ 3-Hydroxypropanal

$\text{H}_2\text{O}$
Acrolein Degradation

Water Metabolism

CH$_2$=CH-CHO
Acrolein

CH$_3$=CH-CH$_2$OH
allyl alcohol

CH$_2$=CH-CH$_2$OH
acrylic acid

CH$_2$=CH-CHO
3-hydroxypropanal

CH$_2$-CH$_2$-COOH
3-hydroxypropionic acid

HOOC-COOH
oxalic acid

CO$_2$

[H] = reduction
[O] = oxidation
[H$_2$O] = hydrolysis

[H] = reduction
[O] = oxidation

[O] = oxidation
9,10-athraquinone
Active against SRB - metabolic inhibitor
Oil soluble
Oil Well Biocide Application
Batch and Flush

- Open Annulus (No Packer)
- Weekly to monthly application
- Dosage
  - 50 to 300 BPD 3 gallons
  - 500 to 1,000 BPD 5 gallons
- Flush water volume based on fluid level (also biocide treated, 2 gal per 35 Bbl)
Fracturing fluids

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Oil or gas zone
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Frac Fluid Biocides

\[
\begin{align*}
&\left(\text{HOH}_2\text{C} - \text{P}^+ - \text{CH}_2\text{OH}\right) \\
&\quad \text{CH}_2\text{OH} \\
&\quad \text{CH}_2\text{OH} \\
&\quad \text{SO}_4 \\
&\quad 2
\end{align*}
\]

Tetrakishydroxymethylphosphonium Sulfate
THPS

38 ppm active
2,2-Dibromo-3-nitrilopropionamide
DBNPA

18 ppm active
Frac Fluid Biocides

Bronopol

\[
\text{CH}_2\text{OH} \quad \text{C} \quad \text{CH}_2\text{OH}
\]

\[
\text{Br} \quad \text{NO}_2
\]
Frac Fluid Biocides

5-chloro-2-methyl-4-isothiazolin-3-one
Isothiazaalone
Flowback of Biocide

Buckley C-3 Flow back Data

Cl (mg/L) and FB (bbls)

Cl, Cum Water, XC575, SCW260

Days Since Frac

Residuals, ppm

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Squeeze Treatment

- Kill bacteria in near well bore
- e.g. 1% acrolein
Battery Treatment

- Batch treatment
  - Heater treaters
  - FWKO
  - Separators

- Slug treatment
  - battery inlet
    - 500 ppm
    - 4 hrs
    - weekly
Pipelines

- Routine pigging
  - Remove water from low spots
  - Removes built-up solids
  - Removes and disturbs biofilm
Batch biocide treatments

- Pig line to remove liquid if possible
- 5% biocide in water or methanol
- Total treatment volume based on
  - length of pipeline
  - estimated water content of pipeline
Comprehensive Microbiological Field Surveys
Epifluorescence Microscopy
Product Selection- Kill Studies
Product Development- Solid Biocides
Research and Development
Training
  - Customer Seminars
  - Scientific Meetings