

MultiScale Simulation Software



# Simulation software for prediction of mineral scaling



## Multiscale simulation software

Over the years, oilfields will experience an increase in mineral scale production due to increased water production and possible sea water breakthrough.

As new reservoir developments become deeper and hotter, with related higher pressures and higher salinity, the problems associated with scaling also increase. These problems present continuously higher costs for the operator, with potentially increased downtime, as well as personnel and material resources required to solve the problems in existing top side facilities and subsea platforms.

Prediction-based knowledge on what kind of scaling problem may occur, will aid in the design and development of equipment to facilitate clean up and prevention of scaling in the production system.

The MultiScale Simulation Software has been available on the market since 1993. The software is continuously being upgraded with new features and data when made available.

The software is extensively used worldwide for scale simulations by major operating companies, research centres (Universities) and chemical producers.

An optimal scale simulation result depends on accurate data and the correct type of samples. Erroneous simulation may be due to poor sampling technique, loss of sample integrity and incorrect analysis methodology. If accurate, essential data is not already available, Expro can offer all the sampling and analysis services needed for your well fluids.

Expro has been involved in the oil service industry for over 35 years and has extensive knowledge and experience in dealing with reservoir fluids. Our services are available worldwide.



# What our technology offers

## MultiScale™

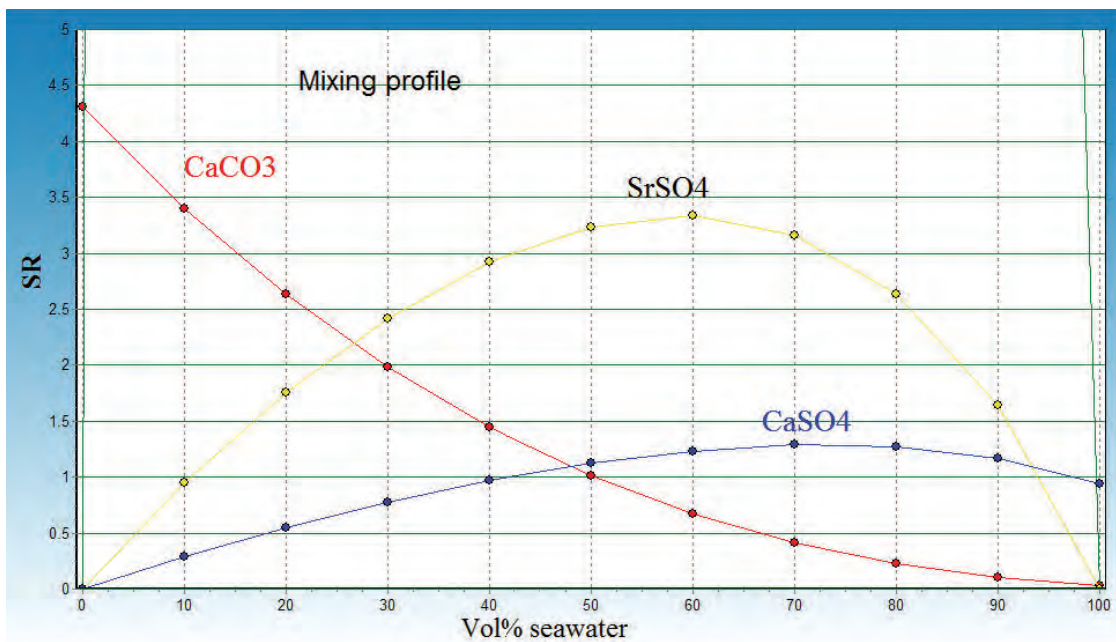
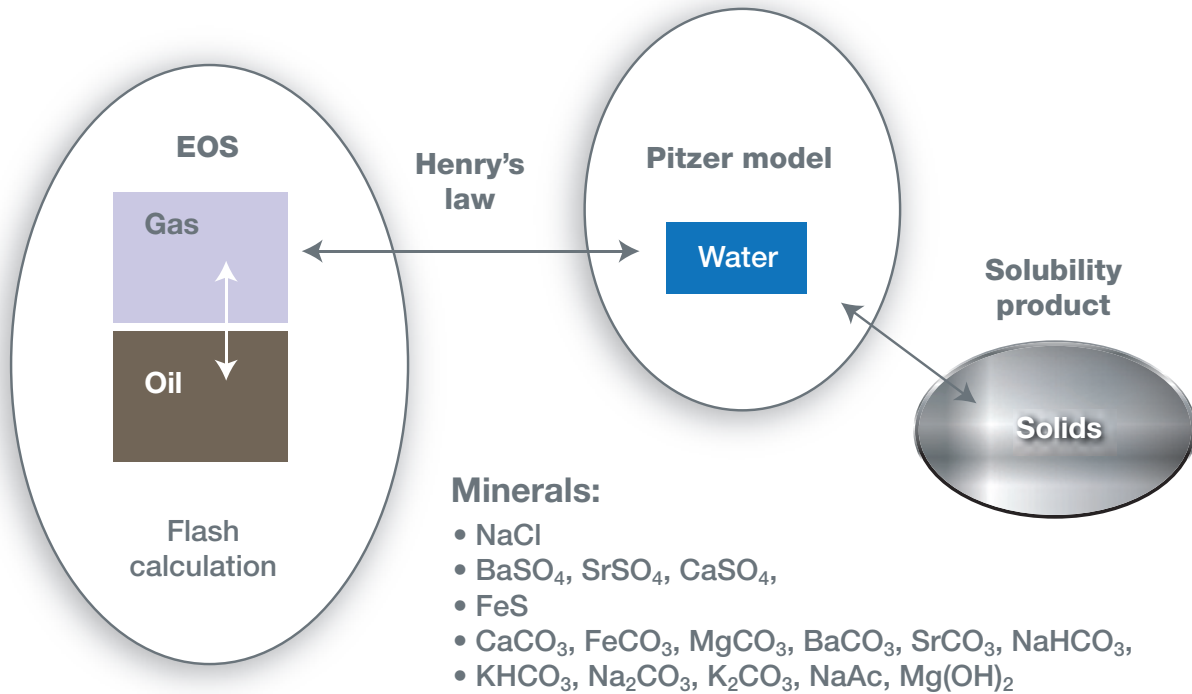
MultiScale is a simulation software developed to help with calculations on the mineral scaling potential all the way through the production system, from reservoir to top side. It is possible to run simulations up to 1000 bar and 300 deg C in salt-saturated systems due to MultiScale's powerful underlying thermodynamic model.

- Accurate model for water equilibria
- Complete PVT-model which can calculate bubble point and phase distribution
- Especially developed to meet the challenges related to the pH dependent carbonate scaling (HPHT wells, injection of produce water, reinjection of CO<sub>2</sub>)
- Very accurate model for calculating evaporation of water at various conditions

## Output variables:

Salt precipitation, pH, chemical equilibria, phase equilibria, water condensation rates, H<sub>2</sub>S scavenger simulation , process simulations, dynamic simulations and more.





# MEG module

## Prediction of scale formation in wet gas condensate pipelines and in MEG regeneration plants.

The MultiScale MEG module is a powerful tool for calculating water chemistry data, solubility and precipitation kinetics for water/glycol mixtures. Multiscale with MEG module gives reliable scale predictions for water - co solvent systems up to 90 wt% co-solvent.

- The glycol regeneration process, the carryover of formation water, the onset of scale formation in pipelines, separators and boilers, and the selection of corrosion rate control methods are strongly interrelated phenomena. Changes in one part of the system will affect the whole process and the results can be increased scale and corrosion problems as well as problems in the regeneration unit. The problem will increase in the future as subsea production makes it even more difficult to control corrosion and scaling.
- The control of corrosion, scale/salt precipitation and hydrate formation is essential for effective gas and condensate production.

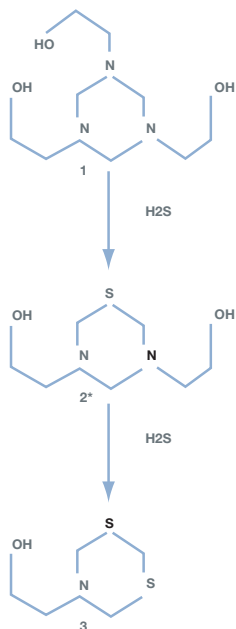


# H<sub>2</sub>S module

The MultiScale H<sub>2</sub>S Module allows the user to see what happens to the scaling potential when injecting a triazine-based scavenger into the process system.

Due to the high pH of scavengers, serious scaling and corrosion problems may occur where this liquid comes into contact with produced water. The MultiScale H<sub>2</sub>S Module enables simulation and monitoring of the pH increase caused by the scavenger amine and hence the change in the scale potential.

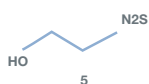
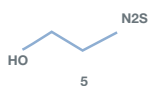
The influence of different rates of scavenger may be logged when combined with the MultiScale process module.



Buhaug, J., Investigation of the Chemistry of Liquid H<sub>2</sub>S Scavengers, PH.D. Thesis, NTNU, 2002.

- (1) 1,3,5-Tris(2-hydroxyethyl)-1,3,5-triazinane
- (3) 5-(2-hydroxyethyl) 1,3,5-dithiazinane
- (5) 2-aminoethanol

\* (2) not included in model



# MultiScale with process simulation module

## Time-efficient process simulation

Calculating the scaling potential for a total process setup has previously been very time consuming, if not practically impossible, with regards to recirculation within the system, or to see how varying parameters influence the process (P, T, rates, different fluids, etc.).

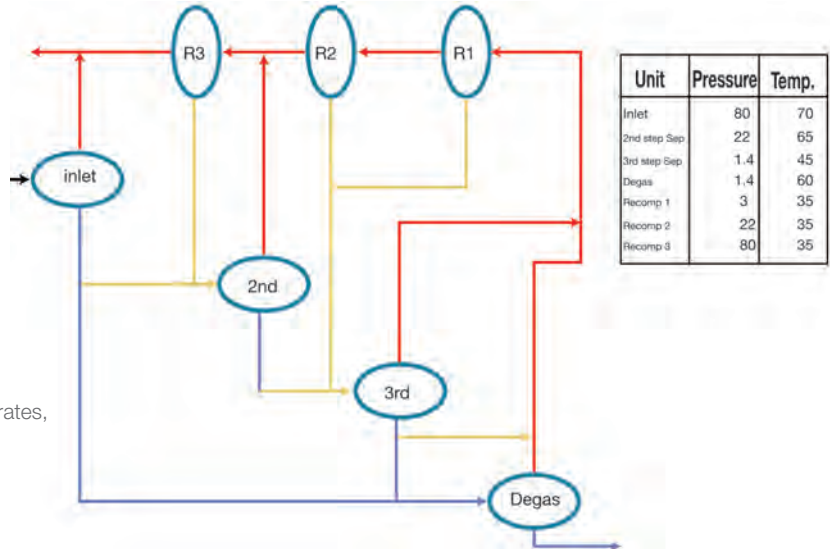
The MultiScale Process Simulation module uses an Excel interface and lets the user set up a full process and run through all of it in one simulation, recording all data for all the units in separate Excel sheets.

### Automatically logged:

- pH
- SR
- flow rates
- ion concentrations in aqueous phase
- hydrocarbon composition for oil and gas

### Optional:

- user defined logging of trends (e.g. P, T, flow rates, calculation convergence, etc.)
- user defined scenarios
- a "virtual process regulator"



### Inlet

Results from calculation of: Inlet

Pressure: 80 bar  
Temperature: 70 °C

Ion concentrations (mole/kg)		
Ions	Initial	Eq
H+	2.81395E-06	2.81395E-06
Na+	0.60333557	0.60333557
K+	0.003939352	0.003939352
CaHCO3+		
Mg2+	0.015840052	0.015840052
Ca2+	0.020853053	0.020853053
Ba2+	0.000120162	0.000120162
Sr2+	0.000313914	0.000313914
Fe2+	7.87971E-05	7.87971E-05
OH-	1.46791E-07	1.46791E-07
Cl-	0.685477364	0.685477364
Br-		
HCO3-	0.015919201	0.015919201
HS-		
Ac-	0.000285668	0.000285668
HSO4-		
SO42-		
CO32-	4.25682E-06	4.25682E-06
H2O		
HAc	2.45822E-05	2.45822E-05
CaCO3o	8.51302E-06	8.51302E-06
CaSO4o		
MEG		
CO2	0.031881895	0.031881895
H2S		
CH4	0.042458513	0.042458513
HFormic		
Formic		
HProp		
Prop-		
HBut		
But-		
AlkT		

### Salt saturation and precipitation

Salt	SR init	Prec1	Prec2	SR eq
FeS				
FeCO3	0.41			0.41
CaCO3c	0.98			0.98
CaCO3a	0.75			0.75
CaCO3v	0.34			0.34
BaSO4				
SrSO4				
CaSO4A				
CaSO4G				
CaSO4H				
NaCl	0.00			0.00
KCl	0.00			0.00
HydroMg	0.00			0.00
BaCO3	0.00			0.00
SiCO3	0.04			0.04
NaHCO3	0.00			0.00
KHCO3	0.00			0.00
Na2CO3D	0.00			0.00
Na2CO3M	0.00			0.00
K2CO3H	0.00			0.00
K2CO3A	0.00			0.00
NaAcT	0.00			0.00
NaAc	0.00			0.00
MgOH2	0.00			0.00
Na2CO3A	0.00			0.00

\*Prec1=mmol/kg, Prec2=kg/d

### Properties of aqueous phase

Prop	Initial	Eq	Unit
pH	5.71	5.71	
w% MEG			w%
Tot CO2	47.814	47.814	mmol/kg
Tot H2S			mmol/kg
Tot CH4	42.459	42.459	mmol/kg
Alkalinity	16.228	16.228	mmol/kg
Density	1.0261	1.0261	kg/m3

### Phase properties

Prop	Total	Oil	Gas	Aq	Unit
Volume	5.849	1.866	3.985	18	m3/day
Z-Factor	0.709	0.539	0.896	0.049	
Density	272.5	710.9	62.8	1.0261	kg/m3
Avg Mw	68.9	158.7	20.1	18.3	g/mole
Enthalpy	-12.380	-26.869	1.361	-42.041	J/mole
Entropy	-32.4	-34.4	-24.4	-111.3	J/mole K
Cp	185.3	317.8	52.4	86.6	J/mole K
Cv	142.6	287.7	35.8	60.5	J/mole K
JT		0.0464	0.3379	0.0203	K/bar

### Mass rate (kg/d) and phase distribution (wt%)

Comp	Total	Oil	Gas	Water	Solid
MEG					
H2O	19.721	2.5	5.6	91.8	
N2					
CO2	29.106	29.4	70.5	0.1	

The MultiScale software is owned by Statoil, but Expro Fluids (by Petrotech AS, Norway) has been licensed to sell and further develop the program.

## Specifications

- Working range: 0-300 °C and 1-1000 Bar
- Mixing of up to 6 waters, 6 oils and 6 gases simultaneously
- Stream calculations
- PVT model, similar to standard PVT packages
- Automatic tuning of water; alkalinity, CO<sub>2</sub> and correction for water evaporation
- Prediction of the water chemistry and the scaling tendency for the following minerals:
  - NaCl, KCl
  - BaSO<sub>4</sub>, SrSO<sub>4</sub>, CaSO<sub>4</sub>
  - FeS
  - CaCO<sub>3</sub>, FeCO<sub>3</sub>, BaCO<sub>3</sub>, SrCO<sub>3</sub>, NaHCO<sub>3</sub>, KHCO<sub>3</sub>, Na<sub>2</sub>CO<sub>3</sub>, K<sub>2</sub>CO<sub>3</sub>
  - NaAc
  - Mg(OH)<sub>2</sub>, MgCO<sub>3</sub>
- With modules:
  - MEG/ water mixes up to 90% MEG
  - Influence on scale potential and pH when adding H<sub>2</sub>S scavenger

## Overview of the MultiScale Applications and Benefits

- Scale potential from reservoir through to topside can be determined
- Scale potential in water/ MEG systems can be determined
- The effect of scavenger addition on the scaling potential for the system can be determined, as well as change in pH (corrosion)
- Suggestions for optimisation with respect to process parameters that are easy to vary can be given; small changes may result in considerable improvements
- Less time spent modelling a given process set up with the Process Simulator module, reducing cost

# MultiScale software

## Expro offers:

- Professional engineers for sampling and analysis
- Knowledge of what data is needed for optimal scale studies
- State of the art equipment for bottom-hole, well-head and separator sampling

## Expro performs scale related analysis on site or in lab:

- Water ion composition
- Alkalinity
- pH at reservoir conditions (HPHT)
- GWR
- HC compositional analysis

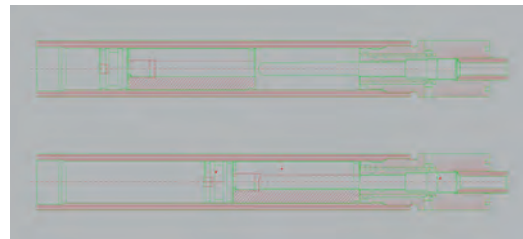
## For additional services:

<http://www.exprogroup.com/fluids>

## High Pressure Laboratory pH-measurements



- pH range: 3-11
- Pressure (max): 0-650 barg
- Temperature (max): 150°C
- Sample volume: 350ccm
- Sample re-usable



Expro's business is well flow technologies and specialised services, and our mission is to:

- **measure**
- **improve**
- **control** and
- **process**

flow from high-value oil and gas wells.

Our expertise is marketed through five segments:

**Well Testing & Commissioning, Production Systems, Wireline Intervention, Connectors & Measurements and Deepwater Intervention.**

Expro offers a fully integrated package of hydrocarbon reservoir and process fluid flow measurement, sampling and analysis services. This data is essential for our customers to enable them to accurately assess reservoir size and production profile, and to optimise design of their process facilities.





**EXPRO**

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