DEQUEST® for oilfield applications
1 Introduction: Scale inhibition in oilfield applications.

Since more than 50 years, injection of water into an oil field has been developed as the leading method for secondary oil recovery, i.e. to maintain pressure in the reservoir and to flood the oil from the subsurface strata into the production wells. This technique was originally used in the North Sea wells and is now extended to more and more oil fields in the world. Scale formation is one of the most important problems encountered in secondary oil recovery.

What factors are responsible for scaling?

The most important sources of scaling in secondary oil recovery are:

- The mixing of incompatible waters between injected and formation waters. Severe scaling can develop after breakthrough of the injection water (sea water) into the formation water. This phenomenon is very well observed after longer mixing residence time in the reservoir. These typical scales observed vary from field to field, for example in the North Sea, the Barium sulphate scales are hard to remove.
- The change of thermodynamic conditions from the bottom to the top of the well (e.g. drop in pressure and temperature).
- Dissolved salts in the waters.
- Temperature applied at various places in the oilfield.
- Pressure variations existing into the pipes and holes of the oilfield.

Scaling tendencies are depending on various parameters such as:

- proportion and type of water injected
- dissolved salts in the waters
- temperature applied at various places in the oilfield
- pressure variations existing into the pipes and holes of the oilfield.

Need for scale inhibitors in oilfield recovery.

When scale occurs various possibilities exist to solve the problem:

In some cases, scales can be solubilised by acids or by sophisticated chemical treatment.

In other cases, when the scaling tendency becomes permanent and serious, preventive scale inhibition is the preferred solution. This involves application of substoichiometric (or "threshold") concentrations of certain polyelectrolytes – e.g. SHMP, polymeric carboxylic acids, organic phosphate esters and phosphonates. The combination of the substoichiometric dosage with large volumes of water involved in oil production makes this method of treatment more economical.

The Italmatch Chemicals S.p.A. DEQUEST® Business is offering unique specialty additives to meet the needs of these industries involved in water management or deal with processes or applications where water plays a crucial role.

More than 40 years ago, DEQUEST® pioneered the development of phosphate based antisalts. DEQUEST® phosphonates have been the product of choice for antiscalants / dispersants / corrosion inhibitors / chelants in various applications for many years. Today DEQUEST® offers a broad range of water management additives including DEQUEST® phosphonates, DEQUEST® P acrylic / maleic based (co-) polymers, DEQUEST® PB biological polymers and tailor made products for specific applications.

DEQUEST® phosphonates and polymers are used worldwide in a broad spectrum of markets and applications, including industrial water treatment, household & industrial detergents, industrial cleaners, enhanced oil recovery operations and various industrial processes such as desalination, pulp production & bleaching of paper as well as textiles.

2 Applications of scale inhibitors in secondary oil recovery.

One can say that a scale problem either exists and has to be removed or is not yet present and a preventive type of solution has to be installed.

Traditional scale prevention by water injection is done either by:
- Continuous injection
- Squeeze treatment

In case of scale removal the ways to solve this problem are either by:
- Acidizing
- Using a scale dissolver
- Fracturing

Additionally, the place where the scale occurs in the oilfield also has an influence on the type of scale. When a scale occurs on the topside, the working conditions will be less stringent. In a downhole scale problem, the conditions are much more difficult because of extreme pressures, temperatures and high salt contents in the waters.

DEQUEST® products can be used in these types of scale problems and the physico-chemical constraints, as well as environmental constraints, will determine the choice of the DEQUEST® to use.

The following scheme illustrates the types of scales.

**The Threshold Effect of Phosphonates**

- Region A: Turbidity Region
- Region B: Effect of pH
- Region C: Sequestration Region

**Increasing molar ratio Phosphonate/Ca**

**THE THRESHOLD EFFECT OF PHOSPHONATES**: This figure shows the functionality possibilities of a phosphonate. It can be used in the threshold region (A), in the sequestration region (C). The turbidity region (B) is where one gets precipitation of the phosphonates in the presence of Calcium.

By knowing this, it is then important to understand which kind of scale occurs so that we can use the right chemicals to solve the scale problem.
The following tables give you the basic physico-chemical data of the various products belonging to our oil field product range:

### DEQUEST® PRODUCT

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical name</td>
<td>Amino tri(methylene phosphonic acid)</td>
<td>1-Hydroxyethylidene (1,1-diphosphonic acid)</td>
<td>Hexamethylene diamine tetra (methylene phosphonic acid)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Molecular weight</td>
<td>299</td>
<td>409</td>
<td>206</td>
<td>294</td>
<td>721</td>
</tr>
<tr>
<td>Appearance</td>
<td>Clear water white to pale yellow aqueous solution</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Active content (as acid)</td>
<td>50%</td>
<td>29%</td>
<td>60%</td>
<td>21%</td>
<td>23%</td>
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<tr>
<td>Chloride (Cl)</td>
<td>&lt; 1%</td>
<td>&lt; 1%</td>
<td>&lt; 0.1%</td>
<td>&lt; 0.1%</td>
<td>&lt; 5%</td>
</tr>
<tr>
<td>Iron (Fe)</td>
<td>&lt; 20ppm</td>
<td>&lt; 20ppm</td>
<td>&lt; 20ppm</td>
<td>&lt; 5ppm</td>
<td>&lt; 55ppm</td>
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<tr>
<td>pH (1% at 25°C)</td>
<td>&lt; 2</td>
<td>2 - 11</td>
<td>&lt; 2</td>
<td>10 - 12</td>
<td>6 - 8</td>
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<tr>
<td>Specific gravity @20/20°C</td>
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<td>1.42</td>
<td>1.45</td>
<td>1.31</td>
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<tr>
<td>Freezing point (°C)</td>
<td>-15</td>
<td>-21</td>
<td>-25</td>
<td>&lt; 5</td>
<td>-18</td>
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### DEQUEST® PRODUCT

<table>
<thead>
<tr>
<th>PRODUCT</th>
<th>D20605</th>
<th>D2066A</th>
<th>D2086</th>
<th>D7000</th>
<th>D2090</th>
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<tbody>
<tr>
<td>Chemical name</td>
<td>Diethylenetriamine penta (methylene phosphonic acid)</td>
<td>Proprietary polyamino-phosphonate</td>
<td>2Phosphono 1,2,4-butane tricarboxylic acid</td>
<td>Bis hexamethylene-triamine phosphonate</td>
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<tr>
<td>Molecular weight</td>
<td>573</td>
<td>617</td>
<td>739</td>
<td>270</td>
<td>685</td>
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<tr>
<td>Appearance</td>
<td>Clear, brown aqueous solution</td>
<td>Clear, dark amber aqueous solution</td>
<td>Clear amber solution</td>
<td>Clear water white to pale yellow aqueous solution</td>
<td>Dark amber solution</td>
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<tr>
<td>Active content (as acid)</td>
<td>50%</td>
<td>47%</td>
<td>30%</td>
<td>50%</td>
<td>45%</td>
</tr>
<tr>
<td>Chloride (Cl)</td>
<td>&lt; 5%</td>
<td>&lt; 5%</td>
<td>&lt; 5%</td>
<td>&lt; 5%</td>
<td>&lt; 8%</td>
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<tr>
<td>Iron (Fe)</td>
<td>&lt; 20ppm</td>
<td>&lt; 20ppm</td>
<td>&lt; 55ppm</td>
<td>&lt; 5ppm</td>
<td>&lt; 65ppm</td>
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<tr>
<td>pH (1% at 25°C)</td>
<td>&lt; 2</td>
<td>2 - 3</td>
<td>1.8 - 1.9</td>
<td>&lt; 2</td>
<td>1.8 - 1.9</td>
</tr>
<tr>
<td>Specific gravity @20/20°C</td>
<td>1.42</td>
<td>1.38-1.43</td>
<td>1.33</td>
<td>1.28</td>
<td>1.23</td>
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<tr>
<td>Freezing point (°C)</td>
<td>-25</td>
<td>-20</td>
<td>-15</td>
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</table>
3 The DEQUEST® product range for oilfield applications.

Our introductory brochure gives you an overview of the whole range of DEQUEST® products available as well as the various industrial application range in which they are currently used. In order to make a primary selection of a DEQUEST® product that can solve the scale problem, the following table has been developed: It provides an overview of the performance of DEQUEST® grades for the inhibition of specific types of scales and some typical applications in which they are currently used.

<table>
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<tr>
<th>PROPERTY</th>
<th>D2000</th>
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<th>D2056</th>
<th>D2065</th>
<th>D2086</th>
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<td>CaCO3 Inhibition</td>
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<td>++++</td>
<td>++++</td>
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<td>++++</td>
<td>++++</td>
<td>++++</td>
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<tr>
<td>CaSO4 Inhibition</td>
<td>++</td>
<td>++</td>
<td>++++</td>
<td>++++</td>
<td>++++</td>
<td>++++</td>
<td>++++</td>
<td>++++</td>
<td>++++</td>
</tr>
<tr>
<td>BaSO4 Inhibition</td>
<td>++</td>
<td>++</td>
<td>++++</td>
<td>++++</td>
<td>++++</td>
<td>++++</td>
<td>++++</td>
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<td>++++</td>
</tr>
<tr>
<td>Corrosion Inhibition</td>
<td>++++</td>
<td>++++</td>
<td>++++</td>
<td>++++</td>
<td>++++</td>
<td>++++</td>
<td>++++</td>
<td>++++</td>
<td>++++</td>
</tr>
<tr>
<td>High T° stability</td>
<td>++</td>
<td>++</td>
<td>++++</td>
<td>++++</td>
<td>++++</td>
<td>++++</td>
<td>++++</td>
<td>++++</td>
<td>++++</td>
</tr>
<tr>
<td>High [Ca] tolerance</td>
<td>++++</td>
<td>++++</td>
<td>++++</td>
<td>++++</td>
<td>++++</td>
<td>++++</td>
<td>++++</td>
<td>++++</td>
<td>++++</td>
</tr>
<tr>
<td>Iron tolerance</td>
<td>++</td>
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<td>++++</td>
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<td>++++</td>
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<tr>
<td>Chlorine Stability</td>
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<td>-</td>
<td>-</td>
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<td>-</td>
</tr>
<tr>
<td>Some typical applications</td>
<td>Topside, low Ca</td>
<td>General Ca</td>
<td>Ca down hole</td>
<td>Top scale Squeeze</td>
<td>Ba scale Squeeze</td>
<td>Topside, Steam flood</td>
<td>Down hole</td>
<td>Topside</td>
<td></td>
</tr>
</tbody>
</table>

+++ = excellent, ++ = very good, + = good, - = satisfactory, - = not preferred

Our technical team and our local sales team can help you in building up the most appropriate solution for you.

4 Performance characteristics of DEQUEST® products.

Static bottle test.

This test is e.g. used to measure the BaSO4 scale inhibition performance under specific water conditions for secondary oilfield recovery.

BaSO4 Scale inhibition (50/50 SW/FW, 95°C, pH 6, 24h, 250 ppm Ba)

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In the following graphs, the CaCO₃ inhibition was evaluated at different conditions in different waters.

**CaCO₃ scale inhibition (LSI 2.7)**
(480 ppm Ca, 600 ppm HCO₃⁻, 60°C, 24h, pH 8.4)

**CaCO₃ scale inhibition**
(Kristin field, 5108 ppm Ca, 975 ppm HCO₃⁻, TDS 82085 ppm, 170°C, pH 7, 24h)
Dynamic tube blocking test. We can use this test to measure CaCO\textsubscript{3} and BaSO\textsubscript{4} scale inhibition performance under high pressure and high T°. Like those one find in the brines or in the formation rock.

Following graph shows for a DEQUEST\textsuperscript{®} the profile in a dynamic tube blocking test. The MIC (minimum inhibition concentration) determination for a specific oilfield can then be calculated from this type of profile and applied for scale prevention or squeeze.

5 Environment

Nowadays, environment is an important parameter in the use of chemicals. The oil industry is well aware of this and various legislations are there and are regularly completed to take into account the impact of oilfield activity on the environment.

Inside Italmatch Chemicals S.p.A. we take this as a priority and have already various DEQUEST\textsuperscript{®} products which can meet the more and more stringent regulations.

For example our DEQUEST\textsuperscript{®} PB 11625 is classified as “GOLD” in UK legislation and is classified as “YELLOW” in the Norwegian legislation. The CEFAS (UK) has also the product on the list of approved products for use by the North Sea Oil&Gas industry.

This process is continuous and we permanently develop new products anticipating the future needs of environmental chemistry.

6 Packaging

Italmatch Chemicals S.p.A. products for oil field applications are available in a whole range of packaging types including 200L drums and 1000L IBC’s.

With our technical team we can help you find solutions to your requirements.
More information

If you would like to obtain more detailed information about DEQUEST® products or are interested in obtaining a sample for evaluation in your system, please contact your nearest Italmatch Chemicals S.p.A. representative or visit our website: http://www.dequest.com

ITALMATCH USA
NORTH AMERICAN HEADQUARTERS
21 East Front Street
Red Bank, NJ 07701
USA
Tel: (732) 383-8500
Fax: (732) 383-8407
info@italmatchgroup.com

ITALMATCH INTERNATIONAL TRADING
(CHINA) CO., LTD
Room 703, Pine City,
8 Dong`an Road, Xuhui District,
Shanghai 200032
P.R. China
Tel: +86 21 3469 1871
Fax: +86 21 3469 1872

ITALMATCH BELGIUM SPRIL
Parc Scientifique Fleming
Rue Laid Burniat 3
1348 Louvain-La-Neuve
Belgium
Tel: +32 (0) 10 48 12 11
Fax: +32 (0) 10 48 14 95
info@italmatchgroup.com

ITALMATCH JAPAN LTD
Burex Kojimachi 5F,
3-5-2 Kojimachi, Chiyoda-ku
Tokyo 102-0083
Japan
Tel: +81 3 5210 3811
Fax: +81 3 5210 3830
info@italmatchgroup.com

ITALMATCH CHEMICALS S.p.A.
Via Vismara 114
20020 Arsenio
Italy
Tel: +39 02 93525237
Fax: +39 02 93525496
customercare@italmatchgroup.com

SINGAPORE OFFICE
ITALMATCH SINGAPORE PTE LTD
No. 1 Kim Seng Promenade
#17-02 Great World City East Tower
Singapore 237994
Tel: +65 6235 6483
Fax: +65 6836 4534
infoasia@italmatchgroup.com

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