

USING LOW SULFATE SEAWATER DURING WATER INJECTION TO AVOID SCALING PROBLEM

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ABSTRACT

A study was carried to see the effect of low sulfate seawater as water injector to avoid scaling problem. In this study, low sulfate seawater was used. Solubility test and permeability test have been conducted to show the effect of low sulfate seawater. For solubility test, six jars contain formation water were used. Seawater and low sulfate seawater (75%, 50%, 25% and 1% sulfate reduction) were added into the jars respectively. The ratio of seawater and formation water in the jar is 50:50. The solubility of sulfate was compared between seawater and five types of low sulfate seawater. For permeability test, six cores contain formation water were used as medium injector. Seawater and five type of low sulfate seawater (75%, 50%, 25%, 5% and 1% sulfate reduction) were injected into the six cores which length 1 in after the experiment to get the mass of precipitation. The significant of temperatures also were considered in this study are 30^oC, 50^oC and 70^oC. Result from the solubility test showed that precipitation occurred in all jars containing seawater and in the low sulfate content seawater but the amount of precipitation was reduced. For the permeability test, it's shown that the mass of precipitation decreased when the low sulfate content was used. The effect of temperature showed that the mass of precipitation decreased when temperatures is increased. It can be concluded that even the sulfate content were reduced to 1% sulfate reduction there may still be a scaling potential and squeeze treatments may still be required.

1.0 INTRODUCTION

Secondary recovery is one of the activities were used to improve oil recovery. In secondary, we have lot of method used. For example, waterflooding and gas flooding. The injection of flooding into the oil-bearing reservoir to increase the primary recovery factor and to maintain the reservoir pressure to make that ultimate oil recovery is a maximum.

In waterflooding, when injecting the water into the reservoir with it is neither thermal nor chemical equilibrium will have a number of effect. The injected water will react both the water already in the pore space of the rock (formation water) and with the mineral in the rock itself. This reaction will create the scale. Inorganic deposits are called "scales" and organic deposits are referred to as "waxes" (saturated hydrocarbons) or "asphaltenes (unsaturated and cyclic hydrocarbons)."

An overview of all possible scale formation environments for seawater is representing in; prior to injection for example if seawater injection is supplemented by produced water re-injection., around the injection well, deep in the formation, in the completed interval of a production well, at the junction of a multilateral, at the subsea manifold, at the surface facilities, during aquifer water production and processing for re-

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injection, and during pressure reduction and/or increase in temperature within any downhole tubing or surface processing equipment.

Scale formation in gas and oil well is a common problem during production, persistent, treatment, transportation, and disposal of coproduced salt water. Scales are mineral that form on a surface due to the saturation of the local environment with an inorganic salt. The major categories of scales of interest to oil and gas production are: carbonates (Ca, Mg, Fe(II)), sulfates (Ca, Ba, Sr, Ra), sulfides (Fe(II) and Zn) and silicates (Ca, Mg, Al and Na). The major scaling problem are found during waterflooding is a carbonate and sulfate scale.

Sulfate scale may result from changes in temperature and / or pressure while water flow from one location to another, but the major cause of sulfate scaling is the chemical incompatibility between the injected water, which is high in sulfate ion and the formation water, which originally contain high concentration of barium, calcium, and / or strontium ion. The common sulfate scale includes barite (BaSO_4), celestite (SrSO_4), and gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$). For carbonate scale, it can be form when pressure or temperature changes in a flowing fluid lead to he break out dissolved carbon dioxide (CO_2) which is accompanied by the scale deposition. The common carbonate scale includes calcite (CaCO_3), siderite (FeCO_3) and aragonite.

For this research, I will concentrate with using low sulfate seawater as water injector. To prevent sulfate scaling occur, the sulfate content must be reduce to certain point where the scaling cannon happen. Therefore, to achieve that target, I will reduce the sulfate content in seawater only, because that impossible to reduce sulfate content in formation water.

The main objective of this study is to see the reaction of low sulfate seawater with formation water whether the sulfate scales are happen or not. The scale can be detected when the precipitation occurs after mixing of the seawater and formation water. This study also, to define the behaviour of the scale exist. The next objective in this study is to analysis seawater and formation water and to analysis the ability of low sulfate seawater as water injector during water injection.

2.0 METHODOLOGY

In this study, two test have been conducted to show the effect of low sulfate seawater as water injector to avoid scaling problem. For the first test, jar test was conducted. The objective of this test is to see the solubility of sulfate scale when seawater or low sulfate seawater mixed together with formation water. For the second test, core test was conducted. Core used as medium injector and then the seawater or low sulfate seawater was injected into the core which containing formation water. The objective of this test is to see the mass of precipitation occurs in core. To see the effect of temperature in existing of scale, jar and core were heated at various temperatures (30°C , 50°C , and 70°C).

2.1 Analysis Seawater and Formation Water

Before these experiments are conducted, analysis of seawater and formation seawater are needed. This analysis consists of cation and anion needed in seawater and formation water. Barium, sodium, calcium, magnesium, strontium, and potassium, for cation and then, chloride, sulfate and carbonate for anion. The ions content in seawater and formation water were taken from SPE paper. Several place of seawater and formation water were considered in conducted the experiments.

2.2 Samples Preparation

Seawater and Formation water

To prepare the formation water, all ions content needed were mixed together. The amounts for each ion have been analyzed in first step in this experiment. Some calculations have been made to get the amount of chemical needed to prepare the sample. The same step was repeated to prepare the sample of seawater.

Low sulfate seawater

In prepared the sample of low sulfate seawater, some calculations have been made. Five level of sulfate content in seawater (75%, 50%, 25%, 5% and 1% sulfate reduction).

Core characteristic

The characteristic of core:-

- i) Permeability = 100 md
- ii) Location = Sentubong, Sarawak
- iii) OD = 1 in
- iv) Length = 1 in

Chemical Needed for Formation water and Sea water

To prepare the sample of formation water, some chemical were needed. These chemicals were mixed together with certain amount depend on calculation. These chemicals are Sodium Chloride, Calcium Chloride, Magnesium Chloride, Potassium chloride, Barium Chloride and Potassium Sulfate

Jar Test

In this test, seawater and 5 types of low sulfate seawater was used. The result using the seawater and low sulfate seawater will be compared each other. These test to see the solubility of scale after seawater or low sulfate seawater mixed with formation water. To see the effect of temperature in existing of scale, the jar heated at various temperatures (30°C, 50°C, and 70°C).

Procedure for jar test is as follows :

1. Prepare 5 jars.
2. Insert the formation water into all of 5 jars.
3. After that, insert the seawater or low sulfate seawater into the 5 jars containing formation water.
4. Shake the jar for 15 seconds after mixing.
5. Lastly, insert the jars into the oven to see the effect of temperature.
6. All steps above is repeated for various temperature (30°C, 50°C, and 70°C).

All these procedures can be referring to the schematic diagram for the core test in Figure 1 and 2.

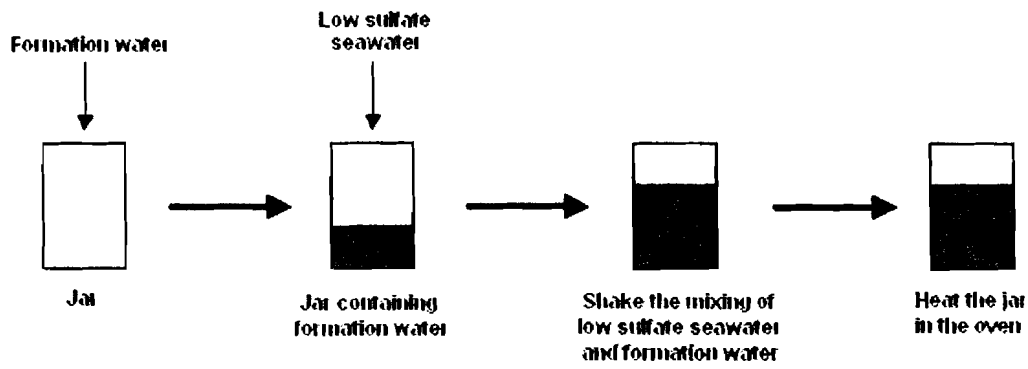


Figure 1: Jar test using seawater

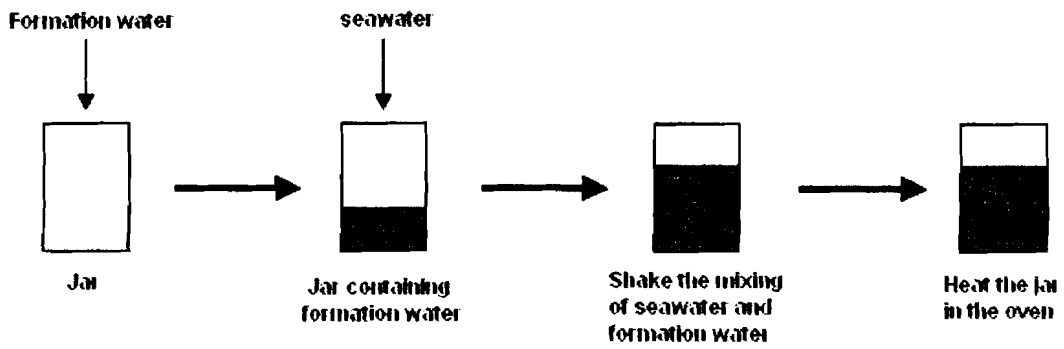


Figure 2: Jar test using low sulfate seawater

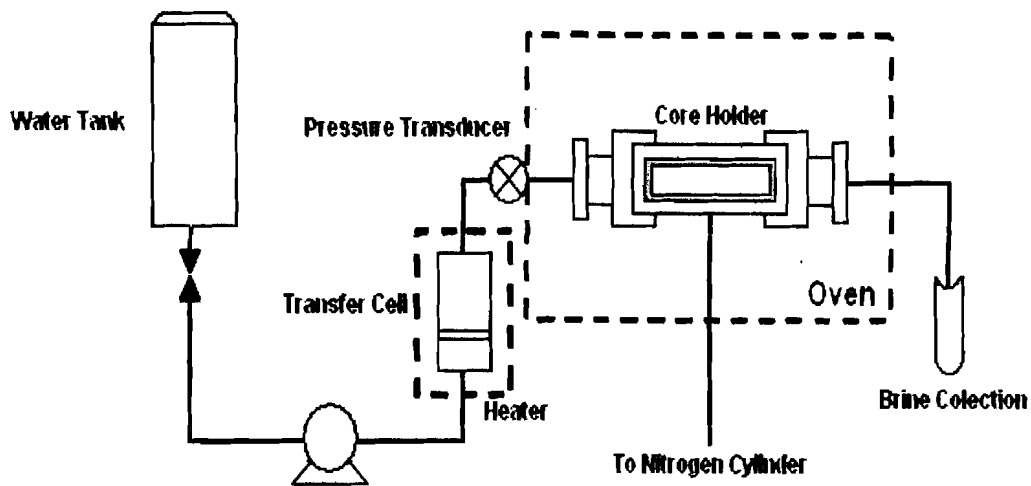


Figure 3: Schematic diagrams for the core test

USING LOW SULFATE SEAWATER DURING WATER INJECTION

Core test

In this test, core was used. Two types of water were used as water injector. That is seawater and low sulfate seawater. The result using the seawater and low sulfate seawater will be compared each other's. These test to see the mass of precipitation after seawater or low sulfate seawater are flowed into the core. To see the effect of temperature in existing os scale, the core was heated at 30⁰C, 50⁰C, and 70⁰C.

Procedure for core test is as follows:

1. Measure the weight of clean dried core by using *Electronic Top Pan Balance* before run the experiment.
2. Insert the core into the core holder inside the oven.
3. Insert the formation water into the transfer cell where locate inside the heater.
4. Start the pump and formation water injected into the core with pressure, 200 psi. Run for 1 hour and for each 10 minutes, the volume of formation water exited the core holder will taken.
5. After injection, the formation water in transfer cell will carry out and it will replace with seawater or low sulfate seawater.
6. Step 3 is repeated for seawater or low sulfate seawater.
7. After 1 hour, move out the core from core holder and dried into the oven.
8. After dried, measure the weight of the core using *Electronic Top Pan Balance*.
9. Lastly, measure the precipitation occurs.

Weight of core (after experiment – before experiment) = mass of precipitation.

All these procedures can be referring to the schematic diagram for the core test in Figures 3 and 4.

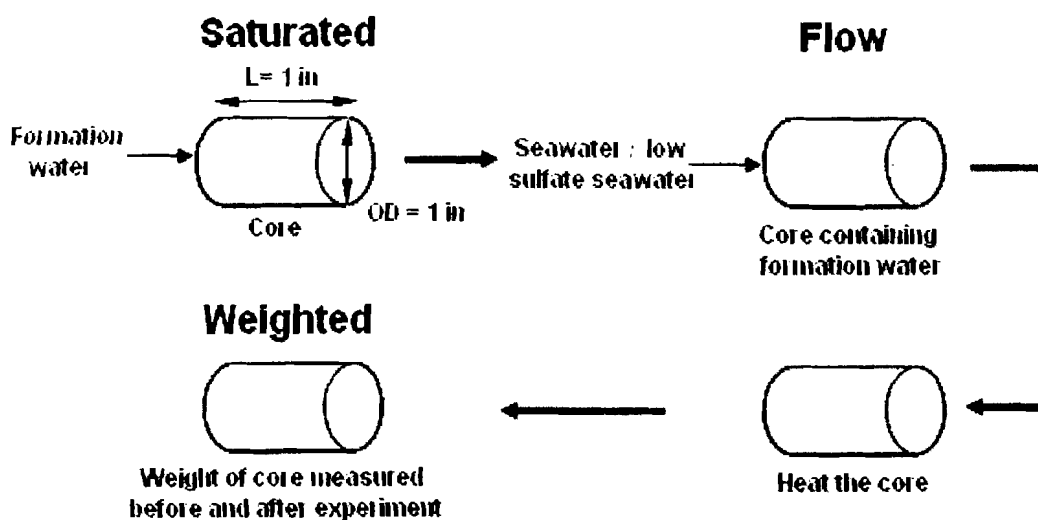


Figure 4 Flow Process for core test using seawater and low sulfate water

3.0 RESULTS AND DISCUSSIONS

This study used data based on Marlim Leste (Campos Basin, offshore Brazil) reservoir brine compositions and conditions. The Marlim Leste field is a deepwater offshore oilfield situated in the Campos Basin off Brazil (Figure 5). The main reservoir age is Oligo-Miocene and the depth is 2700m, in water depths of 800-2000m.

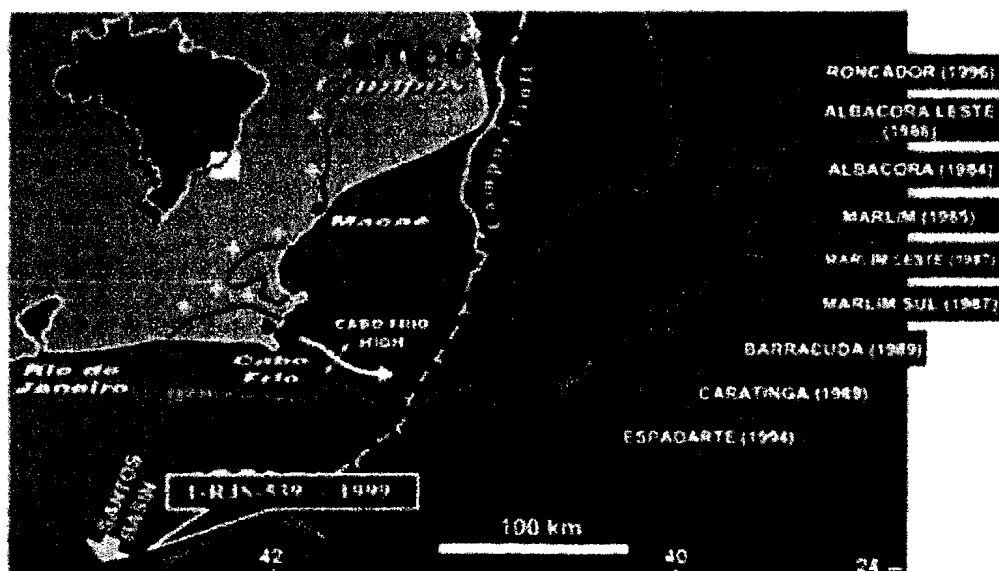


Figure 5 Location map of the Campos Basin Oilfield

Scale prediction

Scale could be predicted based on formation potential was initially uncertain owing to the large variation in the compositions evident in the limited number of formation-water samples. Samples obtained subsequently have confirmed the heterogeneity in water compositions. Table 1 shows the composition of seawater and formation water where it used in these experiments.

Table 1 Composition of Seawater and Formation Water

Constituents	Formation water (mg/l)	Seawater, (mg/l)
Sodium	26,535	10,900
Potassium	1,906	380
Calcium	2,033	405
Magnesium	547	1,300
Barium	80	0
Strontium	417	0
Chloride	48,700	19,800
Sulphate	0	2,780

USING LOW SULFATE SEAWATER DURING WATER INJECTION

In predicting of sulfate scale potential, the theoretical mass of scale formed upon mixing formation water with seawater and the mixing ratio at which it occurs vary, depending on the barium and strontium content.

Core Analysis

From the core test that has been conducted using seawater and low sulfate seawater, it has shown a significant sulfate content in scale existence. Figure 6 shows the effect of using seawater and low sulfate seawater as water injector to avoid scaling problem during water injection. From that graph, we can see that sulfate content in seawater play an important role in existing of sulfate scale. Generally, it could be concluded that the mass of precipitation has increased when the sulfate content in seawater is increased. It means the potential to form the scale is increased when sulfate content in seawater is high.

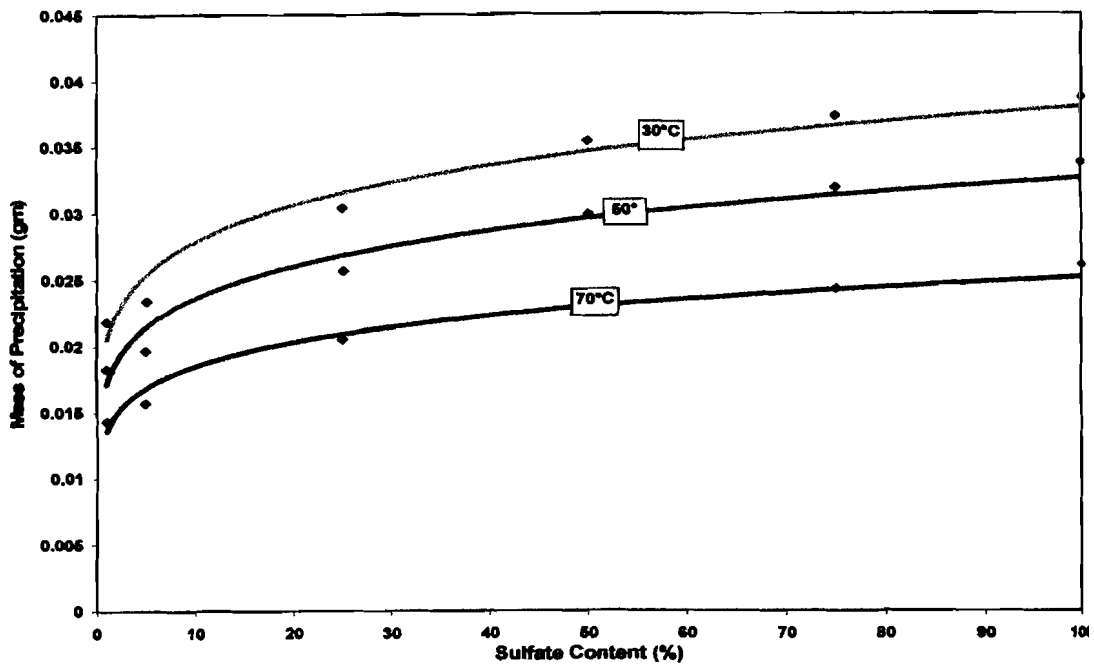


Figure 6 The significant sulfate content in scale existence

When sulfate content in seawater is 100%, for temperature 30°C, we can see that the mass of precipitation which is around 0.04 mg/l. After the sulfate content in seawater is reduced to 75% reduction, the mass of precipitation has decreased gradually. The same results have come out for 50%, 25% and 1% sulfate reduction in seawater.

From that graph, we can see that at 1% sulfate reduction, the precipitation still occurred, but the amount precipitation reduced around 60% then the 100% sulfate reduction. Therefore, we can conclude that even the sulfate content in seawater is reduced to 1% of sulfate, there may still be a scaling potential. Even though using low sulfate seawater could generate scaling potential, it is more valuable rather than seawater in term of water injector. This is because low sulfate seawater only needs a few inhibitors to avoid scaling problem than seawater.

Sulfate scale may result from changes in temperature and/or pressure while water flow from one place to another, but the major cause of sulfate scaling is the chemical

incompatibility between the injected seawater, which originally contains high in sulfate ion, and the formation which originally contains high concentration of barium, strontium, and/or calcium.

Figure 7 shows the effect of temperature in using seawater and low sulfate seawater as water injector to avoid scaling problem. Generally, temperature plays a vital role in scale formation. From the figure above, it also could be concluded that mass of precipitation has increased when temperature is decreased.

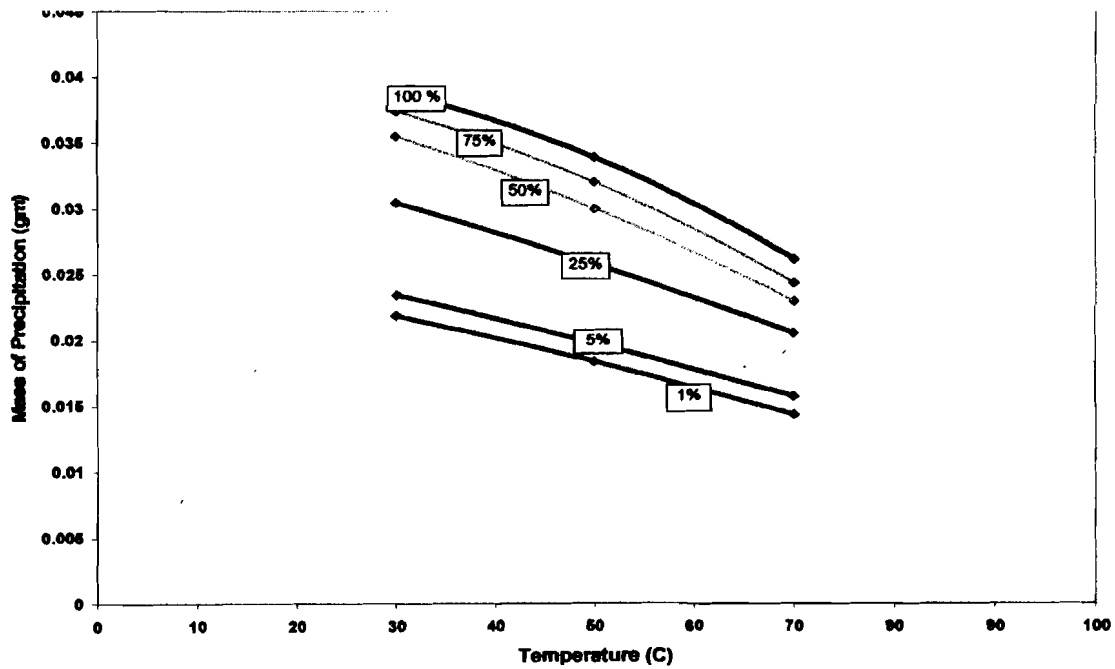


Figure 7 The effect of temperature in scale existence

For 100% sulfate content at 300C, it could be deduced that mass of precipitation is approximately 0.04 mg/l. When the temperature is increased to 500c, it can be found that mass of precipitation has been reduced to 0.035 mg/l. Further increased is temperature indicate that mass of precipitation has also decreased and implies to the other sulfate concentration.

To conclude, mass precipitation is a reciprocal function of temperatures. This is acceptable as it could be seen that scale precipitation occur mainly in tubing rather than in the formation since it is acknowledged that the formation has higher temperature than in the tubing.

4.0 CONCLUSIONS

From the jar test and core test that have been done, we can see that these experiments can be used in predicting the existing of scale. Meaning that, the scale happened when the seawater or low sulfate seawater was mixed with formation water. The scales happen because of incompatible brine mixing between seawater and formation water. Conclusions have been made as follows;

- Even the sulfate content in seawater was reduced to 1% sulfate reduction there may still be a scaling potential.
- Mass precipitation is a reciprocal function of temperatures (Temperature increase, scale decrease)
- Low sulfate seawater can be used as water injector but it needs some inhibitor to avoid existing of scale.

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