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Application of new types of screens to solve the problem of sand production in oil fields.

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Magistr Buraxılış İşi

Neft yataqlarında qum problemlərinin həlli üçün yeni növ süzgəclərin tətbiqi.

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Abstract

During the drilling, completion and production of the wells sand production is one of the common operational problems encountered throughout producing petroleum from unconsolidated reservoirs. It has negative effect on the economy and production and in severe cases, it may lead to abandonment of the well. Furthermore, large amount of sand production can lead to a variety of complications, technical problems, such as erosion of casing.

Sand screen is a mechanical means of controlling sand production and has been considered as one of the effective and widely applied sand control method in petroleum industry over the years. Nowadays, most of the treatments are sand screen which is reliable, cost effective, long term and common sand controlling technique.

In order to achieve an effective gravel packed completion sand screens are the most important part of completion design. All the above mentioned is discussed in the first part of the research report. Additionally, as background information, sand production and causes, confirmation and monitoring of sand production and sand control methods are presented in the first part as well.

The second part of the report emphasizes main points while applying the sand screen methods to the sand producing reservoirs. In Azerbaijan, a number of wells with producing sand are completed with putting sand screens. The operation and other factors are researched through the real field example – West Absheron Field.

Referat

Quyularının qazılması, tamamlanması və istismarı ərzində qum təzahürü neft və qaz istehsal zamanı sementləşməmiş (ovulan) laylarda ən çox rast gəlinən problemlərdən biridir. Bu, məhsuldarlığa və iqtisadi göstəricilərə mənfi təsir edir və çox pis hallarda quyunun tərk edilməsinə aparıb çıxara bilər. Bundan əlavə, yüksək miqdarda qum təzahürü müxtəlif mürəkkəbləşmələrə, texniki problemlərə, məsələn qoruyucu kəmərin eroziyasına səbəb ola bilər.

Süzgəclər qum təzahürünün idarə olunması üçün mexaniki üsuldur və uzun illər boyu qum təzahürünün idarə olunmasında ən çox tətbiq olunan üsullardan biri hesab olunur. Günümüzdə, süzgəclər etibarlı, sərfəli və uzunmüddətli istifadə olunmasına görə həm tükənmiş, həm də normal təzyiqli laylarda geniş tətbiq olunur.

Effektiv çınqıllı süzgəc tamamlamasına nail olmaq üçün qumlu layların qarşısına süzgəclərin qoyulması quyu tamamlanmasının ən vacib hissələrindən biridir. Qeyd olunanlar haqqında geniş məlumat yazının birinci hissəsində verilir. Bundan başqa, həmin hissədə qum təzahürü və səbəbləri, qum təzahürünün təsdiqlənməsi və monitorinqi,onun idarə olunması üsulları da öz əksini tapmışdır.

Yazının ikinci hissəsi süzgəclərin qum hasil edilən laylara tətbiqindən bəhs edir. Azərbaycanda çoxlu sayda qumlu laylardan istismar olunan quyular var ki, onlar süzgəclərlə tamamlanmışdır. süzgəcin iş prosesi və digər faktorlar araşdırmada (Qərbi Abşeron) geniş şəkildə müzakirə olunmuşdur.

Declaration of Authorship

I, Elvin Hajiyev, confirm that this work submitted for assessment is my own and is expressed in my words. Any uses made within it of the works of other authors in any form (e.g. ideas, equations, figures, drawings, text, tables, other forms of data, programs) are properly acknowledged and referenced at the point of their use. A list of the references employed is included.

Signed on

Signature ____

Acknowledgements

I would like to express my gratitude to each person who helped me throughout the research. First of all, I am thankful to my supervisor Mr Elvin Ahmadov for giving me valuable advice and suggestions. Secondly, I would like to thank other professors and engineers for their priceless explanations to my questions. Finally, I would like to thank my workmates and my brother for their help.

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1. INTRODUCTION

Completion methods for weak and sand-prone reservoirs have been done successfully over the period with the aid of sufficient knowledge and years of experience. Open- and cased-hole sand control choices may be applied to the numerous completions, according to the reservoir characteristics and also field experience. In general, sand completion is very challenging option in terms of technical aspect and high cost. Sand-prone reservoirs need to be completed with downhole sand control, because over the time, sand production from the well will be intolerable. In case of absence of downhole sand control, delaying intervention can result in reservoir pressure to drop below the water gradient.

The plan of an ideal sand control strategy and generation administration could be a complex issue due to the synchronous impact of different variables. Normal viable factors for choosing an ideal sand control strategy incorporate topographical, specialized, prudent, and expert's involvement on comparative ventures. A few specialized variables, which influence the ideal strategy, are the sort of avoidance, rock measure of rock pack and pre-packed screen, space width and liner space length, and efficiency list decrease. The circumstance might be more complicated due to the instability related with different contributing components.

Despite the fact that sand control completion is technically challenging, nowadays it is applied in the industry especially in unconsolidated formations due to its reliability. Putting sand screens of sand reservoirs are widely used and vigorous design and extremely clean execution gives good outcomes. In contrast, sand screening of depleted reservoirs is not often applied and successful results are considered as technological and engineering achievement. In general, sand screen completion of reservoirs requires correct selection of sand screen types and techniques available for those reservoirs. Proper selection of sand screen and correct deployment can provide much better and desirable outcomes in depleted reservoirs.

2. Sand Production and Sand Control Methods

2.1. Sand Definition and Occurrence

To expand on the preceding definition, sand is described as sediment having a mean grain size between 0.0625 mm and 2 mm, which, when compacted and cemented, will create sandstones. A significant proportion of sedimentary hydrocarbon reserves are made up of sandstones, as they often have high porosities and permeability. Although the majority of oil and gas deposits identified at the time are in sandstones or carbonates, there are some others that are found in other rocks. Although shale, volcanic rock, and shattered basement rock all have rare occurrences, there are less occurrences of these substances compared to one another (basalt). A comparison of reservoir rocks indicates that sandstones are more abundant, while limestone is the more significant reservoir rock because of its role in hydrocarbon extraction. As may be shown in Figure 1, there is an occurrence and production of oil and gas [1]

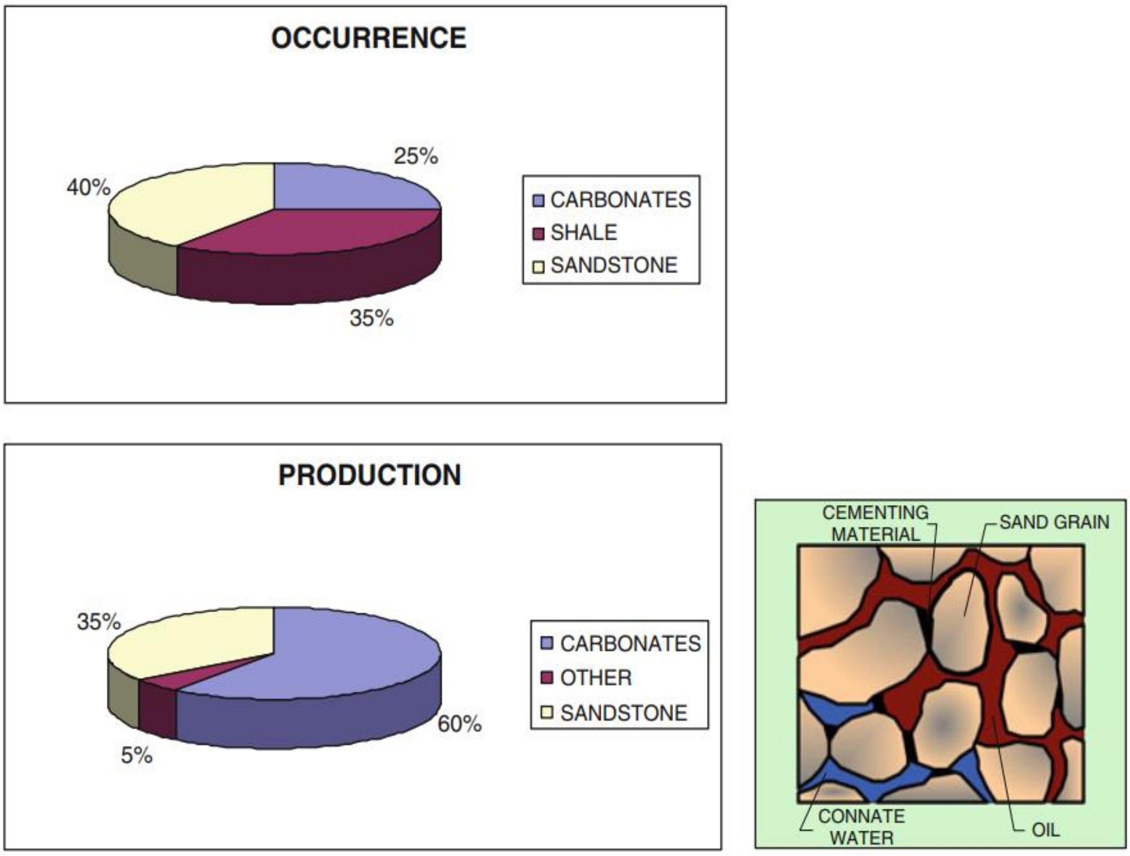


Figure 1. Occurrence and production of oil and gas (Allen and Roberts 1978) [1]

2.2. Classification of Sands and Failure Mechanics

In the instance of trying to assess the risks of sand production, a combination of analogies to other geological places, core inspection and testing, log interpretation, well tests, and field experience might be used. A basic awareness of the rock types that are sensitive to sand production is a good place to start; one can continue by studying the characteristics of specific rock types, such as sandstones and shale. For reference, the categorization of rocks could be found in Table 1. [2]

Term	Brinell Hardness (BHN) ($\frac{kg}{mm^2}$)	Geological Equivalent
Unconsolidated	<2	No cementing material
Partially consolidated	2-5	Pieces easily crushed with fingers
Friable	5-10	Pieces crushed when rubbed between fingers
Consolidated	10-30	Pieces can only be crushed with forceps
Hard	>30	Pieces cannot be broken
- Medium hard	30-50	With forceps
- Hard	50-125	
- Very hard	>125	

Table 1. Classification of rocks[2]

On the basis of visual and physical testing, the wellsite geologist has historically classified rocks into these classes. Van der Vills (1970) proposed the notion of categorizing rocks according to their Brinell Hardness to create a less subjective division for engineering design work on well stimulations (BHN). Brinell hardness is measured by pushing a 3.5 mm steel ball into a polished surface of the material under a defined static load. Because major sand production is mostly related with unconsolidated, partly consolidated, and friable sands, it's important to go over them in greater depth.[2]

Unconsolidated Sands (BHN $\frac{kg}{mm^2}$)-Worldwide, the bulk of sand production problems are found in relatively shallow (i.e., less than 8000 ft [2400 m]), young (Miocene-Recent), unconsolidated rocks. Unconsolidated sands can conveniently be subdivided, in their degree of natural cohesion, into quick-sands and competent uncemented sands.[2]

Quick sands have very little cohesive force or compaction to hold them together. It is difficult to drill through this type of formation as the sand readily collapses into the wellbore. Sand production starts with fluid production, as sand is easily mixed with oil, water, or gas.

Competent uncemented sands result from the increase of in-situ stress with depth, which provides the unconsolidated sand with a degree of natural cohesion, as a result of internal friction. The wellbore will stand open through such an interval, even in deviated wells, although the sand is easily washed away during drilling, completion, or production operations. Conventional coring of such sands is difficult. Rubber sleeve coring can be beneficial sometimes if pump rates are kept under control. A simple perforated completion can sometimes be used in such a formation, although severe sand production is often experienced if the produced fluid has high viscosity (e.g., heavy oils) or once water breakthrough occurs. Some operators use sand control in this type of formation, at least to some predetermined depth, as a standard practice. Without sand control, some degree of continual sand production can be expected, with sand concentration being a function of production rate and drawdown.[2]

Partially Consolidated Sands (BHN 2-5 $\frac{kg}{mm^2}$) - Partially consolidated sands have some cementing agents, but only weak, unconfined compressive strengths. A core can usually be taken from this type of formation with a conventional core barrel, but it crumbles easily. When production circumstances change, an open hole completion is conceivable, but the hole tends to collapse and sand itself off. Similarly, perforated completions are initially stable, but as conditions change, cavities or pockets cave in periodically, especially after sudden rate changes. This causes slugs or clumps of sand to come into the wellbore that may fill the rathole or form bridges in the tubing. Analyses of sand content in produced fluids may show large variations from day to day as the sand is produced at irregular intervals.[2]

Friable Sands (BHN 5-10 $\frac{kg}{mm^2}$) - A friable sand that is well cemented and easily cored is the third type of possibly hazardous and potentially troublesome sand. Cores appear strong and competent and do not look as though they would give sand problems. However, the cementation may fail due to a combination of increased grain-to-grain stress, erosion, and changes in saturation, allowing sand production to occur. This sort of formation is known to create sand for a few days or weeks after completion, then drop to a trace or stop producing sand entirely. Sand production may reoccur with drastically lower pore pressure or water inflow into the well, especially at high production rates when turbulence becomes considerable near the wellbore. Post-failure stabilizing effects, on the other hand, make it exceedingly difficult to anticipate.[2]

The behavioral divisions in the above classification are somewhat artificial, but represent a decreasing probability of sand production. Sand is rarely produced by consolidated and hard rocks, excluding during initial cleanup and testing of poorly finished wells. (In these tougher rocks, frac stimulation is frequently utilized, and frac sand is occasionally produced back into the wellbore.) Rather than a sand management issue, this is the product of improper fracturing operations.)

Although sand production during testing may not suggest a high likelihood of ongoing sand difficulties, even when it results in sand off of the DST (drill stem test) tools, it is crucial to understand that the sand being produced is not necessarily an indicator of how often such problems will reoccur. Porous objects in the subsurface like rock and soil pore spaces can be released and stabilising materials can be applied during natural wellbore cleanout and stabilising operations. Processes are aggravated if most of the output is created by a small number of perforations, all of which must be well maintained and completely closed in order to ensure production. The substantial initial drawdowns lead to an increase in cavity volume and an influx of sand. As in this instance, it is possible to experience comparable drawdown-induced abnormalities when perforation depths are really significant. [2]

2.3. Causes of Sand Production

Sand development should be carefully investigated and analysed in terms of its sources, existence, and implications. If they are made, they have a significant effect on the design of the distribution method. Because of cleaning and disposal costs, a surface gathering system, separating system devices, and some form of surface protected disposal should all be considered. The loss of bearing solid material also affects the formation's stability. Geomechanical assessment, well parameter optimization, directed and selective perforation, and output optimization by regulating drawdown during the wellbore life cycle can all be used to solve the problem.[1]

Most of the sand production in the world is produced by the breakdown of rocks, whether as a result of natural occurrences, human activity, or simply due to the passage of time. Reservoirs may be broadly characterized as having two forces, which are countering or balancing one other. The first property is called the restraining force, which refers to the rock's inherent strength, while the second property is called the drag force, which is caused by the fluid flow. Whenever there is a problem with the rocks, there is always a cause that is secondary to the issue.

The processing of oil and gas is often supplemented by the production of solid particles to some degree. The problem can occur anywhere in the world, regardless of the age of the reservoirs, but it is more common in wells that produce from younger reservoirs. Firstly, as younger formations are weakly consolidated, they are typically very susceptible to sand production and considered as low compressive strength formation. Consolidation of the rock is main restraining force that keeps it together and characterized by the degree of cementation. Cementation materials holds the rock particles together and prevent them from falling. Therefore, insufficient cementing materials lead to formation sand becomes unconsolidated. In such formations, throughout production fluid flow removes the cement materials between grains and fine particles are produced together with hydrocarbons. Fines damage the near wellbore area by plugging the pore throats. As a results, permeability reduction leads to higher drawdown with decreased production.[1]

Furthermore, a significant contributor to sand production is the fact that reservoir pressure is decreasing. To reduce underburden pressure, fluid pore pressure must be adjusted. The hydrocarbon is generated, reducing the pressure in the reservoir, which consequently lifts portions of the underlying rock and begins to release the fluid into the wellbore. A decrease in reservoir pressure may result in an increase in the overburden stress, which is supported by sand grains. When this occurs, the surface area of the cementing materials between grains is decreased, causing the stress to increase. As a result, more sand is formed.

The other factor contributing to sand production is either increased water production or water cut reduces the strength of the inter-granular cementing material. This means that increasing the quantity of water lowers the cohesive forces (also called cohesiveness) between the sand particles. Also, an increase in water cut results in a decrease in the relative permeability to oil, which further increases the pressure difference required to keep production at constant rate. When there is a sufficient amount of pressure difference between the formation and the reservoir, it stresses the formation and prolongs its destruction.

The above described factors are all related to the structure of the rock, which is the major contributor to the amount of sand generated. This fluid flow impact is a bit more in depth: The fluids moving in the formation may contribute to the production of sand. Frictional drag force is created by drawdown, which is in turn proportional to flow rate. When production rate is sufficiently high, frictional drag force combines with effective stress effect and might cause the failure of the rock. This happens eventually in the case of sand production. There are two other effects on fluid viscosity: the viscosity of the fluid itself, and the flow. Since high viscosity fluids have greater friction effects, fluid with higher viscosity causes increased friction in the formation. According to the researches, sanding does take place in the heavy reservoirs even when production rates are low.[1]

The volume and type of cementing substance that keeps individual grains bound together, as well as frictional forces between grains and capillary pressure forces, influence the start of sand processing. It is still necessary for sand to flow from unconsolidated formations. However, it is also probable in high-compressive-strength formations with strong grain cementation. In both cases sand production can start immediately or can happen during the lifetime of well.

Sand production is one of the undesirable situation throughout the production of hydrocarbon as it can lead to various problems both in surface and downhole. Sand production is generally movement of the sand particles which separated from the rocks and produced together with hydrocarbons at the surface. In some cases, sand production is allowable and manageable, however, in other cases, the amount of the sand production may dramatically affect the production. According to its degree, sand production can be classified as follows:[4]

Transient sand production – As time goes on, less sand is produced at the constant production rate. It occurs once every other month, on average, and occurs after a perforation, acidizing, or breakthrough. This production of sand, which has this consistency, may be handled in a simple manner without any management approaches required.[1]

Continuous sand production - A substantial number of cases have shown the statement correct. As long as the concentrated sand production in the produced fluid remains constant, production will remain at the current level. It depends on operational limits, thus the amount of produced sand could be deemed appropriate. In terms of erosion, separator capability, sand disposal or transport possibilities due to well position, and the artificial lift technology used, that is to say, is viewed as. Unconsolidated reservoirs are characterized by features such as these, which are typically thought of as problematic and ought to be dealt with long term.[1]

Catastrophic sand production – is the worst-case scenario. The quantity of sand that is created is well beyond what is tolerable. As a result, the overall chance of the scenario ending in creation of sand bridges in the tubing is high, with resulting great quantities of sand filling the wellbore. The presence of such a high possibility leads to the need for an effective approach. The later that will be explained in further detail.[1]

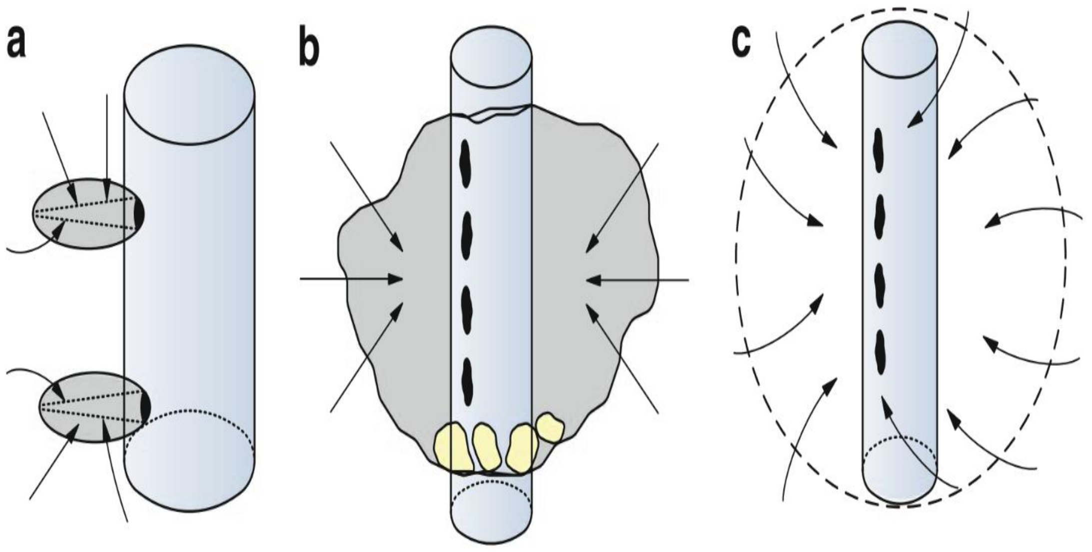


Figure 2. Change in well downhole area geometry due the sand production: (a) Perforation enlargement, (b) Formation of the large cavity, (c) Cavity sloughing[1]

Regardless of the manner in which the sand supply is delivered, there will be a large expansion in the size of the well bore. Following the removal of debris from perforations, it is feasible and expected that some degree of perforation enlargement may occur. (Figure 2a). If such enlargement persists it is possible that to that moment separated perforations may have come together and a large cavity is formed (Figure 2b). The true measure of the volume of sand accumulated over the perforated interval length is the total accumulated volume, including sand that was only deposited within the wellbore. Although a formation may appear to be completely consolidated or as if it is consolidated on a weekly basis, sloughing of sand and even overburden layers is a likely outcome. (Figure 2c) [1]

2.4. Confirmation and Monitoring of Sand Production

Before deciding whether or not to propose that the operator invest in a sand control treatment, it may be required to first evaluate if the well is a prospective sand producer. To discover the most straightforward approach, perform an investigation of the offset wells' production records. Wells which have produced from the same zone have the tendency to produce sand at any point in their existence, thus there is a high likelihood that this well may likewise have the same issue.

When it comes to new wells in an untested location, it may be more challenging. While both a Mechanical Properties Log (MPL) and laboratory core studies may be utilised to study the formation integrity and to anticipate the sand generating capability of a zone, analysis of the rock mechanics via MPL or core studies is necessary. Furthermore, many mechanical instruments are available to continually monitor the sand production from a well, even if it is thought that sand may be being generated at any given moment. In these instances, instruments can be used to measure when a new well begins producing sand as well as to estimate the amount of sand-free production attained following a sand control treatment.

In the process of making a choice as to whether to implement sand management in a specific area, the focus is on an ability to accurately anticipate the possibility of an undesirable sand inflow during a natural plugging. Production engineers and sand control specialists both use a combination of below: [2]

- analogy;
- core inspection and testing;
- log interpretation;

- special well tests;
- field experience.

Analogy – Usually, the first step is to consider the field characteristics, including:

- Geological age;
- Depth of zones;
- Environment of deposition;
- Pressure regime;
- Development concept;
- Fluid type and viscosity;
- Porosity and permeability;
- Primary cementation material.

These are reviewed and compared with similar fields elsewhere in the region and/or the world. It is well known that severe sand production can be expected from:
- young, shallow, poorly cemented, dirt, deltaic sandstones, especially under depletion drive conditions;
- heavy oil wells;
- highly over pressured, poorly cemented sands.[2]

Core Inspection and Testing – To be most effective, representative samples from the reservoir must be evaluated and examined in the laboratory. Due to the heterogeneity inherent in any formation, core samples will vary considerably within the zone. Differences in particle settling velocities cause different particle distribution patterns for produced fines that are entirely dependent on the sample gathering location. Therefore, aggregated samples will not necessarily exhibit the same characteristics as exist in the reservoir. Combined samples are valid only to confirm that a sand production problem is apparent. Whole cores are the ideal sample medium to investigate in the laboratory, as they are most representative of the entire formation. Poor core recoveries are often an early indication of potential sand problems, provided good coring techniques were used. Likewise, if the core breaks apart during retrieval, the risks of sand production must be evaluated. However, it is important to remember that destressing of core material during the trip out of the hole tends to destabilize the formation and reduce the cohesion obtained from grain-to-grain friction. Moreover, weak cements, such as clay, may be affected by the drilling mud and by subsequent handling and storage. [2]

Physical inspection of the core is a critical step that many production engineers miss out. The chances of sand production during the early life of the field are minimal if it looks to be reasonably well cemented and grains are not easily rubbed off or broken.

Engineering measurements on marginal core material should be taken. Special coring methods, such as rubber sleeve or plastic sleeve coring, should be implemented if the rock is particularly weak, and the samples should be maintained by onsite freezing. If this is not practicable, compacting loose sand in a triaxial soils testing cell can provide some insight into in-situ behavior. Core tests should typically include the following:

- cementing materials have been studied using thin section, x-ray diffraction, and scanning electron microscopy (SEN).
- core flow tests, to measure the stability of the sand at different water saturations and flow rates, and its sensitivity to salinity changes
- uniaxial and triaxial compressive strength measurements on dry and water-saturated cores
- Brinell hardness measurements are used to relate tested samples to the rest of the reservoir section.

The objective of this program is to define:

- the type and quantity of natural cementing material used, as well as its water sensitivity
- the presence of mobile fines and their destabilising impact on rock strength
- flow and stress variations' effects on core stability
- the relationship of the tested samples to the untested core, as well as any zones from which no core was retrieved and/or additional wells as determined by log response

This laboratory data can also be used as input to theoretical rock mechanical analyses to qualitatively explain the sand production behavior observed in DSTs (Drill Stem Test) and production wells. Sidewall cores are a useful alternative, as the samples are representative of the individual sections of the formation. Analysis of the material recovered from the individual core barrels is sufficient to allow most laboratory tests, other than flow permeability studies, to be conducted. In extremely water-sensitive formations, studies may be done, in which the tendency of a formation to slough when immersed in water is observed. As stated above, several sidewall samples should not be combined to make one large formation sample, because the aggregate is not necessarily representative of any individual zone. Samples recovered from offset wells may also be useful, taking into account all of the limitations noted above and bearing in mind that the reservoir conditions may vary greatly over the distance between the sample source and the target well.[2]

Log Analysis - A lot of effort has been done in this subject, particularly by the larger companies who, in addition to using their own proprietary methodologies, rely on a significant number of outside resources. To help them more precisely forecast failure of the sand, Schlumberger has produced a mechanical properties log (MPL) and a MECPRO log, which is an analytic methodology used to measure the mechanical characteristics of the sand (Schlumberger, 1989). A number of research papers have been published concerning the use of the borehole-compensated sonic, full-wave sonic, and sonic/density combinations for this use.

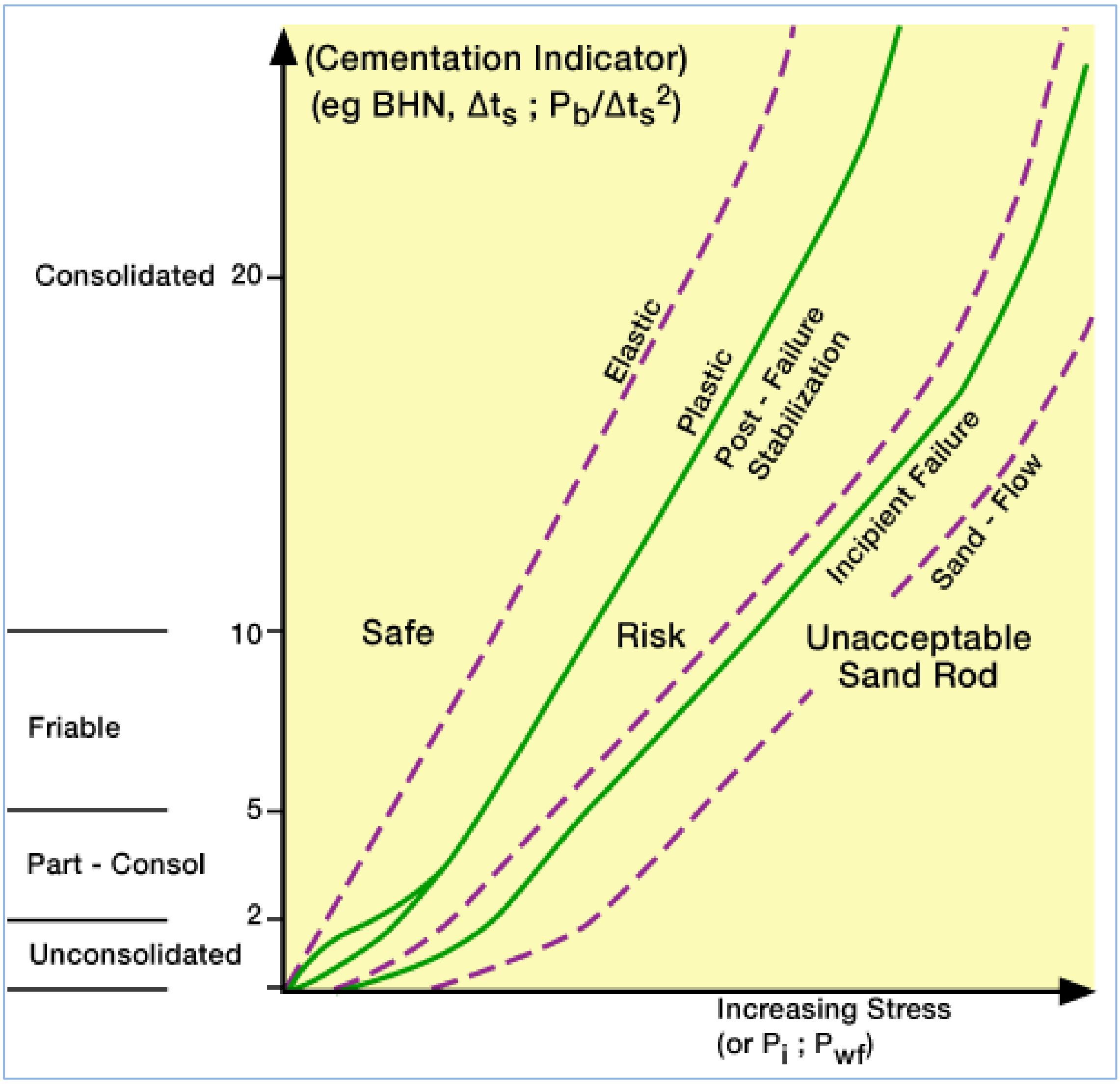


Figure 3. Relationship between cementation indicator and drawdown[2]

On the other hand, all of these tactics incorporate some level of empiricism that serves as a part of their parameters. While their usefulness may be restricted to a certain basin or region, the overall effectiveness of these interventions is limited. In terms of success, some of the more successful log analysis techniques may simply be a refined version of the methodology (published by Stein and Hilchie of Mobil in 1972) known as the approach of charting all test and production data as a graph of sonic velocity (BHCS) vs drawdown to find the safe, risk, and failure zones (Figure 3, relationship between cementation indicator and drawdown).

This is an example of a universal rule of thumb, a principle, or guide to conduct which says that sand production will happen when there is a sonic transit time (STT) in excess of a locally defined threshold, usually ranging from 95 to 110 $\frac{\mu s}{ft}$. While shear modules (G) and bulk compressibility (C_b) are the two most often used sand production indicators, the one proposed by Tixier (1975) using log-derived factors of shear modules (G) divided by bulk compressibility (C_b) is also rather frequent.

$$G = 1.34 \cdot 10^{10} \frac{A\rho_b}{{t_c}^2} \ (psi)$$

$$\frac{1}{C_b} = 1.34 \cdot 10^{10} \frac{B\rho_b}{{t_c}^2} \ (psi)$$

Where:

G = shear modules (psi)

C_b = bulk compressibility (psi^{-1})

ρ_b = bulk density ($\frac{gm}{cm^3}$)

t_c = compressional transit time ($\frac{\mu s}{ft}$)

The constants A and B are related to Poisson's ratio by the following equations:

$$A = \frac{1 - 2\gamma}{2(1 - \gamma)}$$

$$B = \frac{1 + \gamma}{3(1 - \gamma)}$$

Where:

$\gamma =$ Poisson's ratio

Several techniques have been proposed for estimating Poisson's ratio from log response. However, $\frac{G}{C_b}$ is not very sensitive to this factor.[2]

Special Well Tests – There are only two valid means for determining if continuous sand production occurs at initial reservoir pressures. Properly executed well tests using surface and possibly downhole sand detection equipment are the only viable means. In order to get the draw downs and rates needed, the testing and completion equipment must allow for these operations. The test must be conducted even if the initial sand production has ended, as well as through the point at which the sand influx rate shows a noticeable fall, in order to establish that there is no further inflow of sand and/or that, even if there is, production is intermittent. Studies such as this should incorporate step-rate testing with several cycles in addition to long flow durations under low sanding circumstances. To make sure the well is fully completed with an efficient perforation and a cleanup programme, which removes the risk of localized skin effects and turbulence inducing a sanding condition, it is necessary that the well be perforated and well cleaned. In an effort to employ geometric skin effects to replicate the stress conditions that may be expected following reservoir pressure depletion, some operators have performed restricted drawdown testing on a limited number of perforations to see how well the complex skin geometry behaves. Many experts do not believe the results can be trusted since the tests are too difficult to complete, produce exaggerated flow rates, create excessive turbulence, and place the operator in the position of extreme pressure gradients that might be dangerous. In the event that the sand does not remain steady, these outcomes will be negative. Because it is difficult to show the impacts of water breakthrough, it is also customary. However, some operators conduct testing on the quality of the water zones in a well and for backflow following injection into the well as part of their review programmes. [2]

While on the other hand, water shortage is a routine development planning concern, there are also significant implications of resource depletion and/or future water breakthrough. You should focus on operations in the near future (rather than many years in the future) for these future sand control methods. When these future procedures can be postponed and performed before substantial cavity or pressure depletion develops, it is more practicable to use a workover. [2]

Field Experience – At the end of the day, the choice on the sand control needs has to be based on what has already been experienced in the area, which have naturally-perforated completions. However, one must be aware of several factors, including how a task is done, the accuracy of measurements, depth of a well, the pressure in a reservoir, the rate of water extraction, depletion and decline, and development plans.[2]

2.5. Need for Sand Control

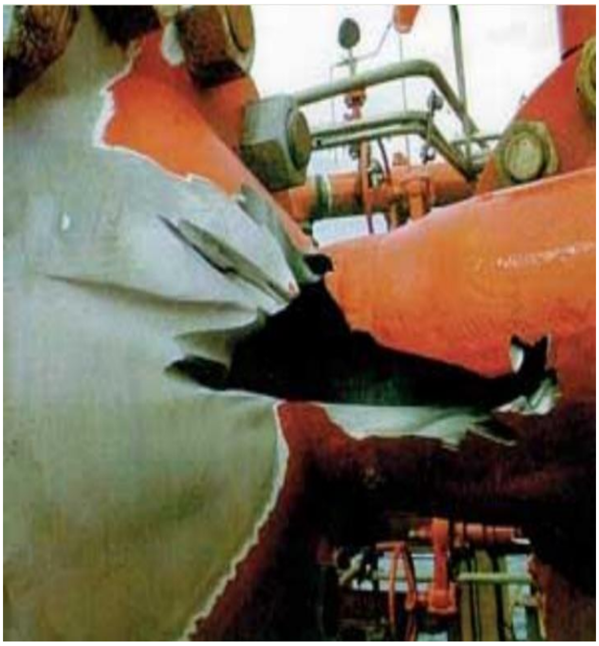
Due to eroded surface equipment, operational issues relating to sand production range from costly sand handling issues to the total loss of a profitable zone or even the risk of lost well power.

Sand Disposal - this is a prevalent difficulty in fields that use unconsolidated sands as a resource In order to counteract these issues, wells with successful sand management systems will often produce a tiny amount of sand. The allowable rate of sand output can vary greatly from operator to operator, and it depends on reservoir conditions and operational logistics. In other words, if sand generation at 0.1% of fluid production results in 5.62 ft^3 of solids per 1,000 BBL of production, then 5.62 ft^3 of solids is what you would expect from a 1,000 BBL production. Although it may be a straightforward and affordable logistics problem to solve on land, producing at modest rates, it would represent a big difficulty to tackle on an offshore platform, where barrels flow through the facility many times daily. Even more crucial is the increased concern about the environment, which necessitates the removal of oil from the solid materials before disposal or which requires the removal of the sand to the coast for disposal.

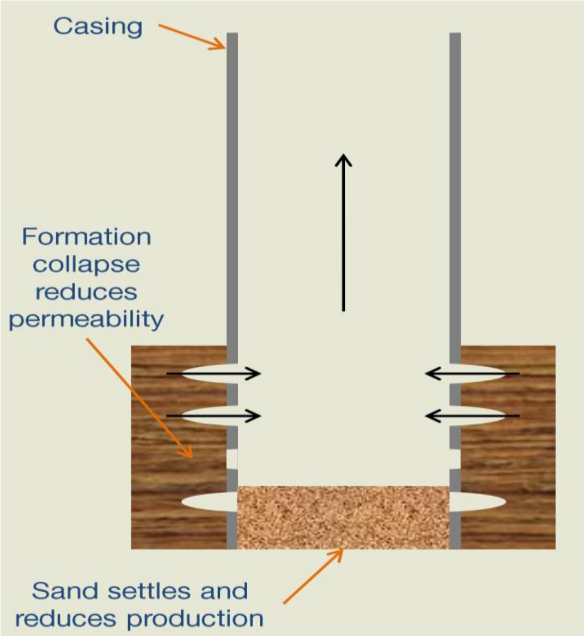
Sand Erosion is frequently occurred in both downhole and surface equipment. Although gravel pack completion tends to prevent erosion of the underlying component, there is a risk of downhole erosion at blast joints, tubing, screens, or slotted liners where gravel pack was not completed properly. Erosion is much more pronounced in the above mentioned scenarios, because it is concentrated in the spots where the sand is being created in gas or where the created fluids are being carried in turbulent flow. Due to the fast velocity of the resulting high-pressure gas containing sand particles, the most dangerous condition is high pressure gas entering the surface choke where it will rapidly spread. If excessive erosion takes place here, it could end in losing effective well control totally.

Loss of Production It is one of the most essential reasons for managing sand production. The loss of production on individual wells could be due to valves in downhole rod pumps and cutout valves in downhole rod pump plungers, or it might be an intentional effort to keep sand movement in control (so as to prevent future production loss). Depletion of the reservoir might happen gradually, appearing to be as if the tubulars are filled with a substance only a portion of the way. Theoretically, using NODAL analysis, you may determine the predicted production rate in relation to the pressure fall in the reservoir. If the rate of the drop is quicker, this suggests the beginnings of a possible problem, such as incomplete bridging. A workover to remedy a sand production problem will likely need the shutdown of a well while the work is being completed. If this becomes required, the productivity and profitability of an entire field is greatly affected. An oil field could have low flowing velocity or gas slugging as a source of bridging of production tubing in flowing wells. The flow rate through the tubing causes the sand to be drawn upwards and released below. Sand is generated when new sand is produced, which leads to fluxing; areas of high sand concentration may result in bridging, possibly at an oil/water contact. For some time throughout the tubing's lifetime, bridges may occur at various locations, which may result in a production string that is packed with sand. While wells may be out of production for only a short amount of time, especially in conveniently placed land wells, they can sometimes be out of production for an extended amount of time or become more expensive in offshore or distant locations. It is possible that because of the high mobilization expenses that more than one well will have to be taken off production to justify the workover budget. The fact that the well is not now in production for several months means it will take many months before a rig moves in. [10]

Casing or Liner Collapse could happen in a well because of decreasing pressure and as a result of production of solids from the nearby wellbore region It has been proven that when formation pressure is reduced in unconsolidated and poorly consolidated formations, this results in subsidence of the formations above the period where the petroleum is extracted. Depletion of the reservoir rock matrix ability to resist overburden pressures leads to a reduction in the level of subsidence. Abandoning or removing the casing could cause the subsurface structure to settle, causing additional radial and axial loading on the structure. The fact that subsidence caused by the underlying gravel layer is limited to subsets of wells with deviations exceeding 45° shows that radial loading, as a result of subsidence, is not excessive in gravel-packed wells, unless there is deviation through the perforated interval. Axial loading is significant and can cause substantial bulging or buckling in the casing if radial support is provided, or bending when minimal radial support is present. In order to mitigate the potential for casing collapse, which can occur when drilling increases radial support and when maintaining reservoir pressure minimizes pressure decreases, it is important to limit the amount of sand pumped down the wellbore in order to maintain radial support and to limit the rate at which reservoir pressure decreases around the wellbore.[10]



a) b)



c) d)

Figure 4. Operational issues related to sand production: a) Sand disposal; b) Erosion; c) Production loss; d) Collapse (Resources - www.DuneFront.com)[13]

As previously mentioned, sand production is undesirable and must be kept under control at all times. When there is an uncontrolled sand production or when the sand rate is exceeded, a number of technical, operational, environmental, and economic challenges are at risk. These three factors—completion interval, tubing, surface and subsurface equipment—are all heavily impacted by the amount of sand being produced. They are listed below in a detailed description:

Completion interval: because the wellbore is filled with sand that has been imported from the bottom, there is absolutely no access to the production interval. Cavity is more likely to form near the wellbore, which increases the likelihood of workover difficulties since isolation in the zonal zones becomes ineffective. When the amount of clay particles in the formation increases, the permeability reduction will become much more significant. Even in the worst-case scenario, if the shale strata are affected, then production may be lost. To compound the issue, there is an increased occurrence of cased rearing in the face of increasing sand production. Full diameter access to the completion interval is lost, and these are two of the other significant concerns.

Tubing: produced sand could create sand bridge in the tubing and reduce the effective diameter of the tubing. This, in turn, causes a decrease in the well production and the reservoirs are lost.

Subsurface equipment: downhole equipment, such as valves, casing, and subsurface safety valve (SSSV), are unsafely operated during the drilling process due to the generation of sand. The sand is accumulated in the accessories, and it might wear down the downhole equipment. This is necessary in this scenario since the equipment must be replaced.

Surface installations: Environmental pollution has always been an important issue. Some settle may occur in the equipment due to the addition of sand particles. Separators, heat exchanger, and other equipment that is located in or around the sanding process is vulnerable. Over time, the sand in the system will increase and lower the capacity of the equipment . Also, erosion may damage equipment and tubes, and if that equipment has to be replaced, or an oil or gas leak occurs, particularly at 90-degree pipe bends, then oil or gas may get into the environment. [6]

2.6. Sand Control Methods

For any kind of sand management, the main aim is to keep load-bearing materials in place. In order to determine exactly what is made, you must first decide on the ultimate result. It is common for fines to be formed, and that can be beneficial since it clears up the pore space. Additional real load bearing solids (ranging between the 50 and 75 percentiles) can be managed by reducing drag forces, mechanically bridging sand, or improving formation strength. There are a lot of important tasks to be done before the well is finished, and that includes work on the drilling, casing cementing, perforating, downhole tool mounting, and so on. A lot of important data needs to be taken into consideration in order to make more accurate predictions about project completion, including reservoir pressure and temperature, productivity index, sand output volumes, water cuts, formation damage, formation permeability, reservoir thickness, and other factors. Everything in this must be meticulously examined and validated to the maximum extent feasible. The production of sand is managed using a variety of approaches. The use of sand control measures is covered in this section. Sand manufacturing might begin as early as the first time it is produced or throughout the process. There have been a great deal of scientific studies that point to the fact that to effectively anticipate sand production and eliminate/control it, the preferred method is to be able to do so. There are numerous sand management procedures which are implemented in order to avoid the sand production. When it comes to sand control, the most common services provided are as follows: [10]

1. Rate Restrictions
2. Selective Perforating
3. Use of Screens or Prepacked Liners
4. Mechanical Prestressing
5. In-Situ Sand Consolidation
6. Resin-Coated Gravel Pack Without a Screen
7. Gravel Packing

Although the methodologies each have a success dependent on their being in the project plan from the start, it should be highlighted that each method's achievement depends on this. With respect to well sand treatments, when a well has started producing sand, the possibility of a successful treatment is greatly reduced due to the movement of sand particles and formation fines around the wellbore.

Rate restrictions It is generally agreed that these procedures should be given priority, as they are the least costly. To highlight the limited economic value of flow limitations, observe that they only help to avoid sand production but do not provide any long-term benefits. When reservoir conditions vary during the lifetime of a well, this kind of sand control becomes increasingly difficult to maintain at the cost-efficient production rates necessary.

Selective Perforating With the use of an MPL (mechanical properties log), engineers able to identify the best part of the pay zone to use. Perforating only in these time intervals will often be used as an interim measure for sand management. To make an assumption that the production on a well within the same field should be limited by the maximum limiting flow rate, which is determined and used as a reference to restrict the production on other wells within the same field. While unfortunately, this approach may severely restrict the maximum recovery rates that can be obtained, the fact that it involves a fixed interval perforated and the requirement of regulating the flow rate depending on the reported formation strength constrain the maximum recovery rates that can be obtained. The predictability of long-term control is also disputed since the mechanical characteristics of the formation might alter with time (e.g., after water influx has begun).

Mechanical control using slotted or wire-wrapped liners without gravel packing The next least priced option is available. This technique is used largely in thick, high-pressure, low-flow-rate periods, such as during injection into high-pressure formations containing formation sand, when pressure decreases may be managed by restricting flow through small slots lined with formation sand. Due to the recent use of prepacked screens containing plastic-coated sand or nutshells, this service has now been expanded to cover formations creating smaller grain particles. In certain situations, gravel pack treatments may be used in combination with prepacked screens to ensure sloughing of the land around the well bore, thereby providing more consistent results. The application of Clay Acid as a complementary treatment to partially stabilize the formation fines should enhance the efficacy of this approach. The study is now focused on screen design, thus it will be explained in greater depth in the following chapter.

Mechanical prestressing By the injection of particle particles into a formation to pack the formation and stress the zone to its original stress levels would be expected to result in the best success rates in short-to-medium thickness formations with nominal silt and clay concentrations. Plugging of the well bore by clay and other possible migratory particles is well-tolerated on a short-term basis due to the development of a broad permeability zone surrounding the well bore, which is less prone to plugging than the virgin formation permeability. Additionally, as water intrusion is not expected to influence performance, the degree of water infiltration would not be expected to significantly impact the degree of water absorption. However, the length of time this form of treatment would be effective would likely be restricted, especially when used at more extended intervals. In particular, it would be difficult to cover the whole zones because of the limitations in reaching total coverage. As of the present, its principal application is as a pretreatment service that is utilized in conjunction with another sand control approach to achieve total zone coverage.

In-situ consolidation techniques, as a solution, have primary application in thin, high-permeability, homogeneous intervals due to the necessity of injecting the chemicals into the entire perforated interval. The use of " Clay Acid " as a carrier fluid for a conventional gravel pack broadens the scope of usage for this in-situ technique, to include all gravel-pack treatments in formations containing 10% to 20% clays.

Resin-coated gravel pack without a screen - should be implemented in thin formations with low clay and silt concentrations. The fact that the wellbore is drilled out after treatment, which allows for a full working diameter for tools, suggests this technique might be of use in wells with multizone completions or wells with limited ID, such as through tubing completions. The likelihood of having all of the plastic-coated particles poured into all the perforations is lowered in lengthy zones or in wells that have a large number of perforations.

Gravel packing, is an effective and commonly applied technique for controlling and mitigating sand generation in oil and even gas wells. The process includes placement of gravel across the perforated area or open hole into the screen-casing or screen-open hole annulus. Gravel is basically round, well-sorted, coarse clean natural sand or synthetic material which are held in place to prevent the production of formation particles, fines and rock grains. In respect to completion, the job is simply to pump gravel slurries and carrier fluid into the annulus around the screen assembly. A follow-up action would be to spread a little layer of gravel over the freshly-placed carrier fluid as it begins to penetrate the formation or circulate back to the surface through the wash pipe. Gravel packing is widely applicable for vertical well originally for years, however, recently it has become rather prevalent for deviated and horizontal open hole wells. Gravel is also widely applied and economical completion type in the depleted an unconsolidated reservoir. There are two types of gravel pack completion: [5]

1. Open-hole gravel pack (OHGP) or external gravel pack is applied, depending on the reservoir, in some locations. This type of pack does not require perforations. It is difficult to manage the particle size of formation sand in locations where the screen does not work directly, and in this case open hole gravel pack completion is recommended. The process is called gravel flooding, and in this procedure, gravel is pumped between the screen and the formation. There is no casing after the completion time is reached. Casing is in place, and the cement is put at the top of the productive interval, while the borehole is drilled through the productive interval below the casing. The installation assembly is installed in the hole and a sand control screen is threaded through it. This well will be equipped with gravel of a quality coarse sand and pumped in. The carrier fluid is combined with gravel sand of a proper size, which has great permeability. This fluid is then sent into the annulus between the screen and the formation, which fills in the spaces between the screen and the drilled hole. Following this, the installation assembly is completely uninstalled. To set up production, the tubing is run and the well is placed on production. The gravel prevents formation sand from entering and the screen prevents the gravel from entering, which prevents fluid from entering. The major function of using screens in gravel packing is to keep the gravel, and, as size of the screen openings must be chosen properly. The type and amount of gravel that is used in the sand pack is important in managing sand penetration into the wellbore. By using a complete open hole gravel pack, a stable and long-lasting downhole completion can be created where only well fluid are produced, rather than formation particles. [5]

2. Cased hole or internal gravel pack has a lot of similarities with open-hole gravel pack technique. When it comes to cased hole gravel pack, there are some key differences. The first is that it is installed inside the pre-perforated casing or liner, and allows multiple zone completions. Based on this, when in hole gravel pack design, perforation method and gun system should be chosen carefully and suitably to maximize the efficiency of the gravel pack while minimizing perforation damage. A unique characteristic of this particular gravel pack is that it can be used to treat reservoirs with reactive shale. In case-hole gravel packing, there will be some perforation filled with gravel and this will lead to turbulence in the perforation tunnel and thus, to the erosion of the hole. As a result, it is crucial to pack all of the gravel into the tank. The process of cased-hole gravel packing involves three primary steps, which include the following: Packing strategy, sand and gravel selection, and fluid selection and gravel placement. All of the parameters necessary for the achievement of high level of completion must be considered before making any decisions. Skin factor is difficult for both open and cased-hole gravel pack. On average, this raises skin pressures and provides negative skin interpretation, which says that production is negatively impacted by pressure drop. Figure 5 shows the both open hole and cased hole gravel pack techniques. [5]

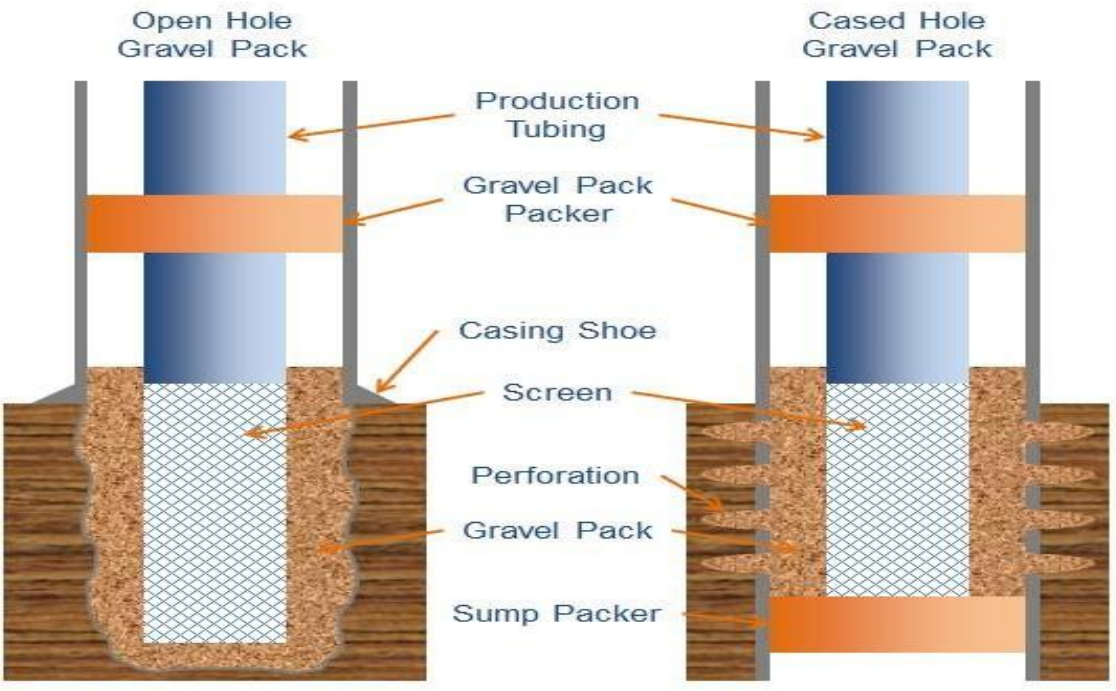


Figure 5. Open and Cased hole gravel pack (Resources - www.DuneFront.com)

Table 2 gives information about sand control methods selection based on their characteristics.

Methods	Wellbore restrictions	Sand size	Sand size distribution	Installation Cost
Screen	Yes	Medium/large	Broad	Low
Consolidation	No	All	All	Highest
Gravel pack	Yes	Small/medium	Medium/broad	Medium
Resin coated pack	No	All	All	High

Table 2. Sand control method selections

2.7. Choosing the appropriate method of sand control

The wide variety of methods and equipment currently available, together with the improvements in the average success of various approaches, suggests that the ideal sand management approach should be selected based on a combination of factors. Sand control strategies may be quantified and compared according to the criteria against which they can be evaluated. [3]

1. Reliability- This is crucial, and it is especially important in cases like subsea fields/wells. The most common effect of a sand control failure is the side track and abandonment of a well. While always being careful with historical data on reliability, one must exercise care when using historical data on reliability in order to guarantee that the environment is comparable, the tools and procedures have not improved, and a valid statistical method is applied..

2. Productivity – To be useful in the context of economics, the reservoir completion productivity needs to be transformed into production profiles that are comparable. Also, a major profile need is that it contain the upper completion impact, reservoir depletion, and water and/or gas influx.

3. Cost – In order for the costs to be comparable, they should be comprehensive. Equipment and installation costs such as pumps, generators, computers, and hoses all need to be included as well as associated costs such as increased drilling time due to using a water-based mud prior to using an open hole gravel pack, the use of additional wiper trips for an expandable sand screen, and a longer length in the reservoir section because of different trajectories and reservoir section lengths.

4. The ability to control water or gas – It may be necessary to do reservoir modelling to accurately assess the advantage. Active water/ gas control is the main technique used in this recipe, which permits an alternate production profile to be developed. To do reservoir modelling, reservoir simulators commonly include keywords to automatically represent the shutoff behavior.

5. Fluid compatibility – To screen for mud-type dependent choices, usage in the preliminary design stages is crucial. However, when screening for choices that need mud types, it is also useful to use in the early stages of design, as most alternatives with mud types are experimental.

In order to have a clear understanding of the first two criteria (reliability and productivity), doing a physical test is highly suggested whenever possible. Some of the approaches include:

a) A mixture of slurry, when applied to the screen, helps in testing of the clogging and consequently the erosion potential of standalone screens. It also helps in testing of the expandability of expandable screens.

b) Gravel pack with a core of casting for testing of fines invasion.

c) A change in fines production and permeability occurs with increased stress (all techniques, especially compliant versus non-compliant techniques).

d) The analysis of sand particle size. Though it is not a direct experiment on any sand exclusion method, it may be quite useful for comparisons between fields and for screening at a high level. [3]

Table 3 serves as a quick reference to assist in selecting the most appropriate method of sand control.

Method	Productivity	Reliability	Cost	Zonal Isolation	Major short-comings
Rate Control	Low due the maximal fluid velocity allowed	Small due the changes in formation through the time	No cost in comparison with other methods	Dependent on type of completion	Constant sand monitoring, separation, and disposal required. Erosion problems and potential loss of production
Selective and oriented perforating	Lower due the restricted flow area opened to the formation	Dependent on available data on formation strength and heterogeneity	High due the perforating and orientation tool expenses	Good if primary cementing was checked	Homogenous formations are problematic. Need for formation strength data and theoretical analysis
Standalone and expandable screens, slotted liners	The highest when no plugging	Poor in heterogeneous formations can be improved by inflow control devices and good testing	Low, but some expenses rise due the amount of sand production, disposal costs	Some improvement achieved by the use of swellable packers (more information needed)	Zonal isolation may be a problem, possible plugging and screen collapse, erosion or damage during installation

Frac packs	High in moderate and heterogeneous formations	High reliability (need to control proppant flowback)	Very high (chemicals, proppant, pumps, mixing equipment	Problematic if fracturing into water or gas contacts	Risks of tip-screen out and proppant flow-back on production
Open hole gravel pack	Good if proper fluid selected and complete volume packed	Minimal skin if no fines invasion exists, possible with water encroachment	Medium because some extra equipment costs rise due pumps and fluid mixing	Almost none	Under-reaming necessary. Reduction of productivity index
Cased hole gravel pack	Better control than open hole due the known volume	Positive skin factors due the change in system permeability	High cost according the casing run, cementing and perforating	Very good due the selectivity and large zonal isolation	High cost of installation and operation complexity
Chemical Consolidation	High but depends on volume covered	Smaller than original	Very high	Very good	Acceptable only for short intervals. Problems with placement may impair reliability

Table 3. Comparison of main sand control method [3]

Wellbore Configuration - Ideally, if it is believed that sand production is occurring, the most effective sand control treatment should be included in the planning session to start the well. Regardless of the technology used to restrict the flow of sand in the wellbore, the various sand control techniques generally include implementing some form of flow restriction around the wellbore as a filter. The design is designed to selectively enable the passage of fluids while inhibiting the passage of solid particles. The size of the gravel particles used, and consequently, the permeability of the filter, is determined by the size of the particles that must be controlled. For highly capable formations that produce tiny diameter particles or when the wellbore diameter is fairly small, the resulting differential pressure across a gravel pack may be really high, resulting in a considerable decrease in productivity. Using larger particles to increase the permeability of the filter (and hence reduce the differential pressure) might produce a loss of control since the forming particles penetrate the filter and limit fluid flow rates even further. We see two changes here: we increase the outside diameter of the collar to expand the collar's point of pressure drop, while maintaining the same permeability. This will lead to a lesser differential pressure, without causing either a significant loss of productivity or an undesirable loss of control. Planning ahead to complete the well as an open hole completion would prevent a filter having a maximum outside diameter that's too large, but a filter of that size can be milled out or over reamed, and in the case of an open hole completion, a filter would be limiting the outside diameter of the well to a much larger value. When it comes to pressure drop, high pressure might cause trouble for the filtration system (i.e. the filtration system might malfunction). If that is the case, an open hole completion or a bigger casing should be used. Instead, in situ sand consolidation techniques should be considered to improve flow capacity, even though they may be less restrictive on the flow capacity. After these techniques have been determined and analyzed, the comparative risk factor and economic analysis should be done for these different methods. [10]

3. Mechanical Control/ Screens

Mechanical methods of sand management use slotted liners, screens and gravel pack (or mixture of both) to keep sand in formation. There are three simple design criteria here:

1. Slotted liner or screen slot depth that is optimal (with and without gravel).
2. Optimal gravel size and distribution are determined.
3. Technique for effective positioning.

3.1. Types of screens

Slotted liner - A steel tubing or casing having a series of axial slots is called a slotted liner or pipe. (See fig. It prevents the wellbore from collapsing by providing mechanical support to it. Horizontal wells drilled into unconsolidated, high permeability sands produce high-viscosity oil, which is one of the most prevalent applications. The sand grains must be carefully sorted and the formation must be thoroughly cemented in this situation. This type of completion has a short producing life before the liner fills with sand if the formation is not thoroughly sorted and the produced sand is not clean with large grain sizes. Because fluid cannot convey even small formation grains through the well to the surface in lengthy horizontal portions accompanied by low inflow rates, this is the case. Due to the low economics of such wells, sand control systems such as slotted liners are commonly used.

Figure 6. Slotted liner (drillingformulas.com)

A controlled layer of sand should be based on bridging, while slotted liners are used to contain gravel. Thus, in order to manage sand, a second sand filtering zone should be installed, and that is why the primary motivation for installing gravel packed liners is to improve sand management. To ensure that the majority of the formation sand remains in the formation, the slots should be as small as possible. This application is simple and inexpensive. Because the slots get plugged, the flow rate drops in cased-hole completion, which calls for the use of a liner or screen, without the use of a gravel pack.

Wire-wrapped screen is a base pipe with holes, longitudinal rods, and encompasses triangle shaped wire that is manufactured on wrapping machines (Figure 7). It offers continuous space between succeeding turns. 1 cm intervals are established around the screen's inner diameter, as the wire is positioned in that space. The wire spacing between horizontal wires should be both narrower and more exact to obtain a stable gap as demonstrated in slot pipe. A wire wrap filter is made up of a series of curved wires which are helically wrapped (wrap wire) around longitudinally oriented wires (rib wire). wrapped wire generates a precise gap between the adjacent wraps, so providing the "filtered" passage for the effluents to flow through. To keep solids out of the production stream, the space between the measurement ports, measured in gauges where 8 gauge is 0.008 in., is sized to prevent them from passing. The width of the wrap wire is 0.090 inches, which is the width of a Standard Wire Wrap Screen. Any wrap wire width between 0.090 inches and 0.100 inches signifies High Flow Wire Wrap Screen. Additional, wrap wire heights larger than 0.088 inches are regarded as being in the Heavy Duty Wire Wrap Screen category. On a scale to compare this with slotted liner, this will be able to preserve finer grained formations and grant a larger flow area. Wire-wrapped screens are used in conjunction with the gravel pack to provide additional stability. Wire-wound screens can be used to complete gravel pack jobs; in this case, the wire wraps the screen to collect gravel, while the fine materials will either be stopped by the gravel or be produced through the screens. It helps to retain the gravel within the annulus between the screen and the formation. [10]

The Hi-Flow screen is similar to the Standard and Heavy Duty Wire Wrap Screens in the sense that it is also a jacket type screen. Again, the difference being that the Hi-Flow screens use a wrap wire width smaller than 0.090 in. The advantage of the narrower wrap wire is that this results in a higher open area of the screen jacket. To make use of this higher open area, the base pipe used in Hi-Flow screens is perforated to a 10% open area. The Hi-Flow screen also uses the slip connection.

Figure 7. Wire-wrapped Screen (drillingformulas.com)

The Direct-Wrap Wire Wrap Screen The wraps are applied directly to the ribs and base pipe; the wires are put in place on the base pipe and then wrapped around the rib wires (Figure 8). In the process, the overall dimensions of the product were reduced slightly. Another benefit of welding to the base pipe is that in some cases it can be eliminated. This screen has a base pipe perforation that allows the base pipe to support the rib wires of the Direct-Wrap Screen, resulting in a more reliable collapse rating than an equivalent perforated base pipe without the rib wires. On the other hand, for Direct Wrap Screens, a thicker wrap wire is developed in combination with the direct wrap process, resulting in a much more robust screen. [10]

Figure 8. Direct-Wrap Wire Wrap Screen [10]

Pre-packed screens just a modified version of the standard wire wrap screens. the screens are made up of two concentric wire-wrapped screens, and between them is a mixture of gravel mixed with resin (Figure 8). The main advantage of gravel packs is that they keep the annulus area between the sand screen and formation free of sand, which stops sand failure and sand transport. A pre-packaged screen neither expands nor contracts. However, they have the ability to filter some substances to a certain extent, and the very high porosity and permeability make it so that the amount of resistance in the water is minimal. The thickness of the gravel layer can be altered to accommodate special requirements. After the screen is packed into a large box, the screen is generally placed in a special oven, where it is heated to high temperatures for a long time in order to cure and harden the resin. Once this is done, sand grain to gravel grain consolidation will take place, followed by permeability promotion, which helps to maintain the formation in place. Screen slots are built and specified in a way to keep the gravel from escaping between the screens. Screen set with dual wire wrapping is supported by perforated pipe. the Pore throat diameter is narrower due to the use of gravel that has been coated with resin and the decrease in the flow area (3 -6 percent). The technique is usually employed when gravel packing is not economically or technically feasible. Even premium screens and the simpler wire-wrapped screens have largely replaced pre-packed screens in new installations, but pre-packed screens are still used by some end users in areas with the greatest needs. [10]

Figure 9. Pre-packed Screen (halliburton.com)

Premium Screen It is made up of multiple layers of woven wire mesh, which together form a filter. The first two layers are for mechanical strength, while the second layer out is the actual filtering layer. The outer layer is there as a protective layer to protect the mesh while in the manufacturing process. In order to create a stable mesh tube, the layers are sintered for mechanical integrity. This prevents the pore openings in the weave from changing under mechanical loads. On the premium screen, the complex open area of the sintered laminate works in a variety of ways. First, the area can serve as a filtration system that is capable of filtering even uneven sands. Additionally, premium screens have larger openings, and because of this, they are more erosion resistant. Instead of using that high open area to its fullest potential, a perforated base pipe is used in a premium screen assembly where 10% of the pipe is left open. A perforated base pipe will be used, and in between that and the filter medium of the premium screen, there will be an inner drainage layer. The inner drainage layer is a stainless steel square or helically wound course mesh, typically three wires per inch, that serves as a standoff of the mesh from the base pipe and offers an axial flow path for the well effluents to flow along the base pipe to the perforations in the base pipe. Perforated shrouds are usually installed around the outside diameter of the filter medium. In addition to these other two functions, the shrouding component of the screens is made to shield the mesh from any damage incurred during shipping and while running in the hole, while also delivering the screens' maximum burst rating. the protective shroud, which acts as a barrier between the filter medium and the outside drainage layer, offers the possibility of a second drainage layer, the outer drainage layer In addition, the outer drainage layer serves to ensure there is a gap between the filter medium and the shroud. Full exposure of the mesh to flow keeps the mesh surface highly exposed to erosion and results in higher erosion resistance. When under injection conditions, lower pressure drop across the mesh lowers the risk of bursts. Three-inch safety edges at each end is the terminating style for the sintered filter cartridge mediums. The safety edge adds a great edge for welding the filter cartridge to the end ring, helping to protect the mesh from being compromised during the welding process, and it also protects the mesh from being sensitized during the heat treatment process. Figure 10 shows the structure of premium screen.

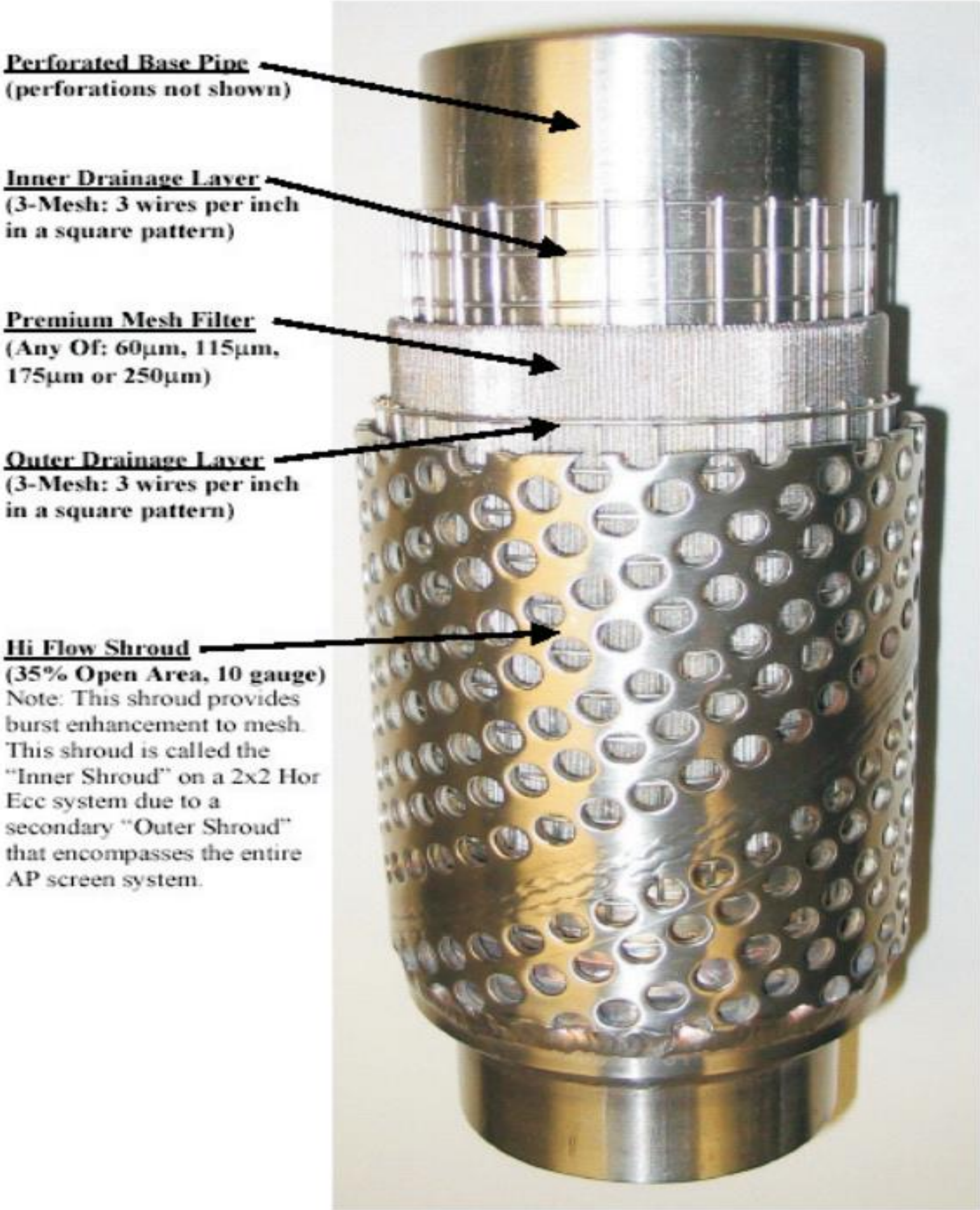


Figure 10. Premium Screen Construction [10]

Expandable screen- A higher well cost should be considered when installing traditional sand control equipment, particularly if it is gravel packed. The primary justification for switching from traditional to expandable displays is to save time and resources. Regular sand control assembly and gravel packing deployment is not only a more difficult (safety and operationally) but much more costly operation than expendables deployment. Expandable screen is a new technique in sand control and consists of expandable slotted tubular (Figure 11) that is produced by cutting the slot pattern through the stainless steel. The annulus is eliminated as expandable screens are used, leaving more space for downhole tool manipulation and borehole support. This eliminates the need for gravel packaging and allows for sand exclusion. Expansion of the tubular is just to swage the diameter of the pipe to the larger size by passing the tapered mandrel. Expandable screen encompasses three main layers namely, expandable slotted base pipe, filter and outer protection layer. Filter is woven mesh sand screen especially designed for expandable screens and attached to base pipe in a way that expansion can be accommodated. It can be applied to the weak formations and permit them to bear high depletions. Expandable screen is not applicable for the gas production. It provides wellbore stability and removes possibilities of the annular flow. [10]

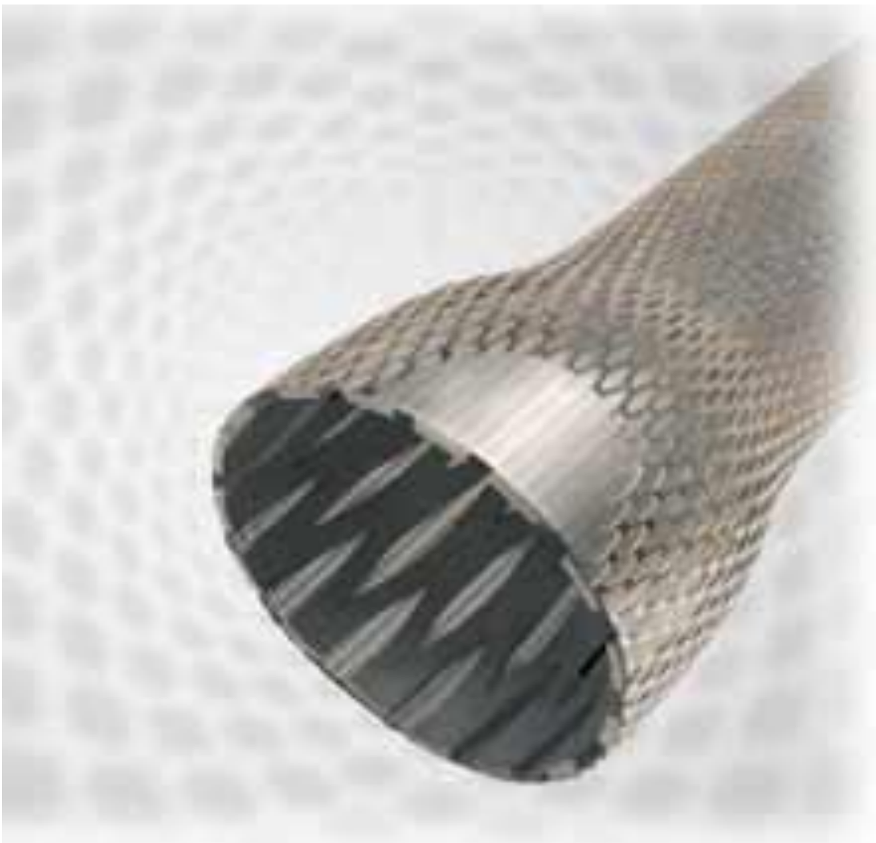


Figure 11. Expandable Screen (oilandgasonline.com)

A expanding mechanism is forced downwards through the string to expand the screen. Figure 12 shows three popular methods for doing so fixed diameter cone expansion, fixed rotary expansion with rollers, and hydraulic expansion. Driving a conical wedge along the string and rubbing it against the wellbore wall achieves cone expansion. For a secure trip out of the hole, the screen normally extends a little more (2–3%) than the wedge diameter. The rollers are expanded by applying pressure to the pistons, which force the rollers towards the screen, expanding it. In comparison to other types of expansion, this one is completed relatively quickly. Where massive forces are used to enlarge the screen, hydraulic expansion is used. The expansion cone, piston, anchors, and a valve with the proper seat size for the ball make up the assembly. As the anchors grasp the extended screen section, the ball secures itself to the valve seat, and the piston pushes the cone downwards as a result of surface pressure. This method of expansion moves at a much slower pace than the previous one. Expandable joints may be expanded up to 80–100% of their original diameter using one of these techniques. [3]

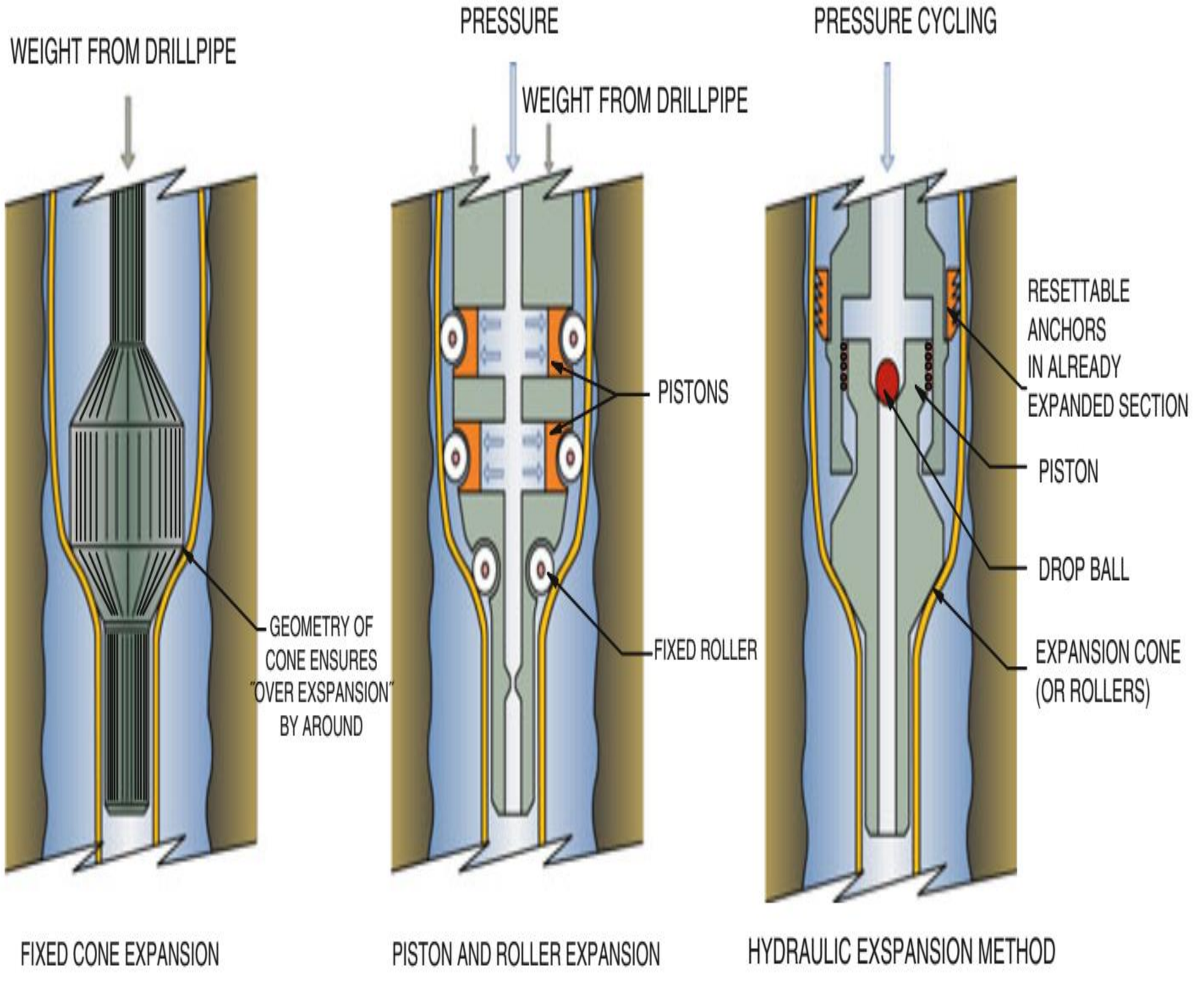


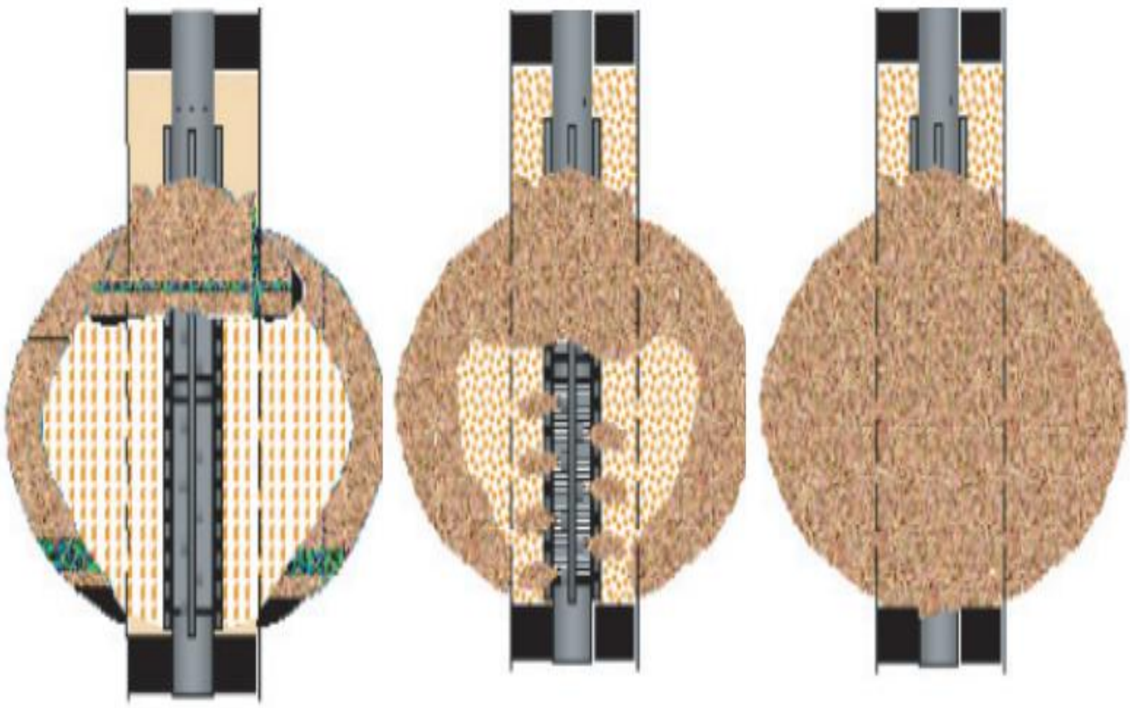
Figure 12. Expandable screen expansion method [3]

Advantages, disadvantages and applications of the mentioned sand control methods with better comparison are tabulated in the Table 4.

Item	*Slotted liner*	*Pre-packed screen*	*Wire-wrapped screen*	*Expandable screen*
Advantages	-Lowest cost -High density slot patterns	-gives minimal pressure drops because of high porosity and permeability -cost effective than gravel pack	-having self-cleaning properties -greater inflow are (5-12%)	-easy and safe installation -improve reservoir inflow -gives lower skin -better for weak formations
Disadvantages	-limited low area -minimum available slot size	-having greater complexity -increased cost -greater flow restriction -highly prone to plugging	-chemical treatments and acid job damage wire -prone to erosion and damage	-can stick to the wellbore and may be irretrievable -cannot be used in highly washed out wells
Applications	-Shallow formations with high permeability -Coarse sand grains	-be applicable with all sizes of sand grains	-higher productivity wells with medium grains	-be applicable with all sizes of sand grains -medium rate oil wells (more than 10-15000 bfpd)

Table 4. Summary and comparison of the main sand screen methods

Alternate Path Screens- In some cases, a standalone screen (without the gravel pack) can be used. In this situation, the formation sand in open hole completions is controlled solely by the screen. The issue with isolated screens is that their service life is frequently limited. The standalone screen often plugs and creates hot spots unless the formation sand is thoroughly sorted and clean, with a big grain size (high-velocity flow with abrasives). Erosion and screen failure will occur as a result of these hot spots.



Step 1. At some point after the slurry arrives, a bridge forms at the top of the screen. Without Alternate Path this would be the end of the gravel pack treatment.

Step 2. The Alternate Path tubes allow slurry to bypass the bridge and the gravel packing treatment continues.

Step 3. A gravel pack is achieved with 100% annular pack and complete packing of all perforations and fractures.

Figure 13. Concept of Alternate Path technology[10]

A gravel pack can be placed around the screen to prevent the concerns mentioned above. Gravel of a known size is placed between the screen and the wellbore wall in this situation. The gravel pack prevents formation sand from forming. The screen keeps the gravel pack in place. The grain size and distribution of the formation sand are used to determine the size of the gravel particles. The screen slot is smaller than the gravel pack grains of the smallest size. The gravel pack is built up around the screen by pumping gravel slurry around it. The slurry's carrier fluid returns up the hole through the screen via a wash pipe, while the gravel remains in the annulus between the screen and the borehole wall. Gravel packing has the drawback of causing early bridging if sufficient leakage to the formation (thief zone) occurs. The wellbore annulus is sealed off by a gravel bridge in this case, preventing gravel from entirely packing downstream of the bridge. The Alternate Path system was created to solve the problem of premature bridging. The essential idea behind Alternate Path technology is that slurry must travel along a different path to avoid forming a bridge in the annulus (Figure 13).

Tubes having exit ports separated throughout their length are attached to the outside of the screen and blank pipe (often referred to as shunts). There are no exit ports on shunts on the blank. These shunt tubes offer the essential slurry bypass routes around the bridge. The tubes become the paths of least resistance as soon as a premature bridge forms, and slurry flows through them to fill holes beneath the bridge. Slurry travels via the exit nozzle until the pack is completed when it reaches an exit port with a void in the annulus pack opposite the port. The slurry is then redirected to the next void space either through the tubes. This technique continues until all perforations and fractures are entirely filled throughout the wellbore. The resulting packets are quite compact. To pack properly, the Alternate Path system requires increased viscosity. In addition, the Alternate Path's entry must extend considerably over the screens, at least a foot over the gravel pack. Shunt tubes are commonly found between one and three joints of blank pipe above the screen. The shunts' function is to give slurry an alternative path to avoid premature bridging. When operating as an alternate flow path, the shunts must be large enough to minimize friction loss. Shunts, on the other hand, should be tiny enough to fit correctly on the screen and into the wellbore. Jumper tubes are used to connect the shunt tubes to the different screens. A short tube with rectangular connectors makes up the jumpers. The jumper tube and connectors are slipped across the interface of the jumper tube and the screens' shunt tubes, and the connectors are slid into the area between shunt tubes on two mating Alternate Path screens. Internal O-rings in the connectors act as a seal, preventing slurry from exiting through the connectors. The slurry exits the shunts through the tubes' nozzles. The size of the nozzle port is determined by a number of parameters. An optimal standard solution has been determined through engineering and testing. [10]

Cased Hole Alternate Path Screens- Alternate Path systems are available for open hole and cased hole applications. These screens generally consist of a Wire Wrap or Premium screen that has shunt tubes mounted along its full length. (Figure 14)

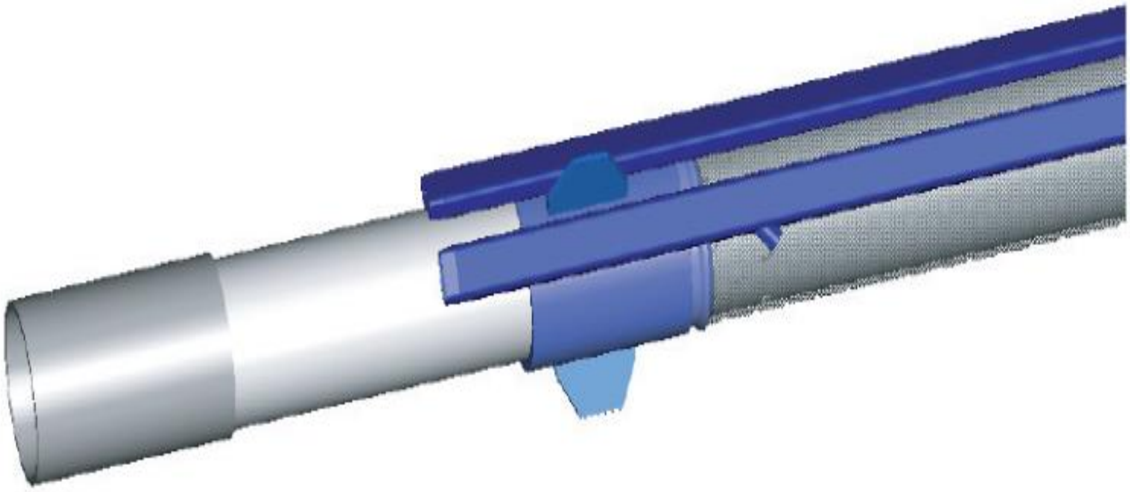


Figure 14. Cased hole alternate path screen[10]

Open hole Alternate Path Screens - A special Alternate Path system is available for open hole applications. The slurry is transported from joint to joint using transport tubes in this mechanism. Each joint contains two packing tubes that are connected by a manifold to the transport tubes at the top of the joint. The nozzles on the packing tubes deliver slurry to the space between the screen and the wellbore. (Figure 15)

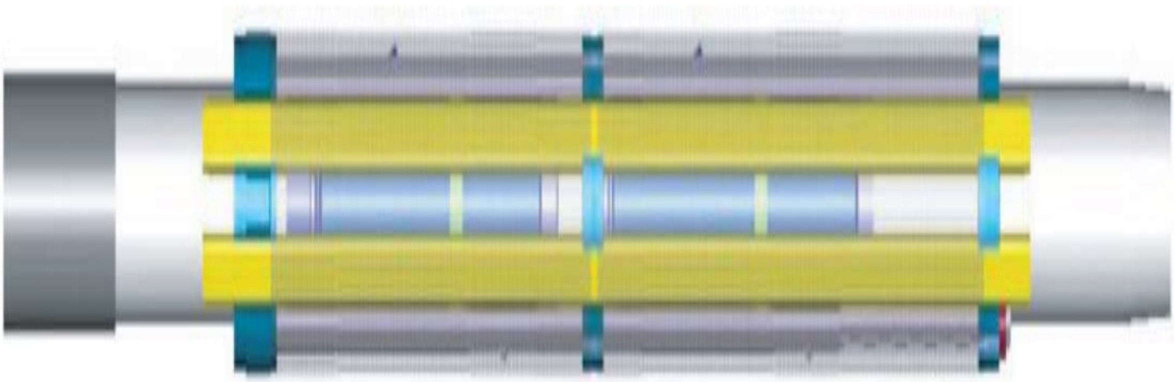


Figure 15. Open hole alternate path screen[10]

To avoid causing any damage while running in the hole, this system uses a shroud to shield the screen components. Simultaneously, the shroud centralizes the assembly in the open hole area, making it possible to consistently obtain a homogenous pack around the screen. To serve as an intelligent completion, this shroud is built with a channel that includes a space where fiber optic cable is placed. The fiber optic line is kept in place by finger clamps, which are spaced at approximately 6 feet intervals. When working with long-screened strings, a centralizer should be used to strengthen the resonance of the group. The centralizer lowers the drag of the screen on borehole imperfections, helping to ensure that the screen makes contact with the ground and arrives intact.

3.2. Screen Design and Selection

Proper design and selection of screens is the most important factor should be encountered before deployment. Henceforth, while choosing screen type and design wellbore conditions such as pressure, temperature, environment with corrosive gas (H_2S) and etc. must have been taken into account.

3.2.1. Screen Design

There are certain parameters that play an important role while designing screen. They are below:

1. Material Selection- is selected in order to withstand with the wellbore conditions. Standard service screen construction consists of 304 stainless steel wire wrapped jackets assembled on API, new, seamless tubulars (J-55 or K-55 grades). When bottom hole conditions are highly corrosive (H_2S, CO_2, high-temperatures, etc.) a more corrosion resistant and higher-strength material should be investigated. The next step above 304 stainless steel for oil and gas use is 316L stainless steel which has better corrosion resistance and strength and is normally assembled on J-55, N-80 or L-80 API, new, seamless tubing. If availability and cost are not a determining factor, 316L stainless steel is recommended for standard service screens as they provide added insurance and they exhibit better corrosion resistance and welding properties than other 300 series materials. For hostile environment completions, the screen liner (wire and pipe base) can be constructed entirely from corrosion resistant alloys such as Inconel 600, Incoloy 825, Hastelloy C-276, etc.). Galvanic corrosion between screen jackets and a base pipe of dissimilar materials does not appear to be a serious problem based on many years of operating experience in the Gulf of Mexico. Laboratory tests have shown that corrosion susceptibility is limited when the screen jacket is welded to the pipe base with appropriate corrosion resistant filler materials, such as stainless steels.. There are no definitive material criteria for tubulars used in gravel pack screen systems. Because there are so many variations in each well condition, material choices for each one must be different..

Corrosion guideline- Generally, if CO_2 is present with a partial pressure of less than 3 psi, carbon steel pipe is sufficient. With partial pressure in the range of 3 to 30 psi a 300 series stainless steel base pipe may be required. Above 30 psi partial pressure corrosive will result requiring 304 stainless steel or higher grade base-pipe. The presence of H_2S may cause hydrogen embrittlement/sulfide stress cracking in materials with a Rockwell hardness above 22 Rc.J-55 or L-80 tubulars should be utilized rather than N-80. Strength of Materials- Since the gravel pack setting is very short in comparison to the tubing string length, J-55 material has sufficient tensile and column strength for most completions.[10]

2. Screen Diameter- There are six factors that may be considered in deciding on screen diameter. These are:

a) Inflow area – High productivity well may require high inflow area. Wire-wrapped screens, normally used in a given casing size, have ample inlet area to accommodate flow through perforation. Inlet areas in slotted liners are much more critical. With all-welded screens, flow rate as high as 500 BOPD/ft of screen results in pressure drops of only 3 to 5 psi.

b) Gravel placement- is more easily accomplished when there is at least one inch radial clearance. This allows moving the slurry through the annulus with low resistance and causes less bypassing of the carrier fluid. Excessive bypassing of the carrier fluid can result in gravel bridging and incomplete packs.

c) Pack thickness- Laboratory experiments have shown that only a three to five-grain diameter thickness is required to create a stable bridge. But this conclusion was based on the assumption that the bridge will not be affected by variations in flow conditions. One of researcher’s work has shown that the bridge will not remain stable if there is formation-sand encroachment. A thicker pack will improve the pack stability. Increased thickness of the pack in open hole does not create additional drawdown and will have only a nominal effect in cased holes.

d) Ability to fish the screen out of the hole- Radial clearance of 1 inch is a rule of thumb number that will help maintain sand control and provide a screen diameter that will allow washing over to retrieve the screen.

e) ID for logging/wireline tool clearance and ID for clearance on selective tubing assemblies- Clearance between the borehole wall (open hole) or the casing ID and the screen for fishing operations and gravel pack must be considered. Additionally, ID of the screen should have been taken into account for future logging operations, deploying selective equipment, or productivity calculations.[10]

3. Screen length – Screen length should be adequate to reach the minimum of 5 feet (about 1.5 m) below the perforations. A substantial overlap (30 ft) above the top perforations may be necessary for low-viscosity gravel loading slurries. This provides the full perforated interval with gravel coverage. In some cases, two completions must be completed in areas which are very near together and the recommended length of the white pipe above the perforated interval should not be used. The conventional approach is in this scenario to run an additional screen above the drilling. This process enables for the deposit of reserve gravel before screening out. Typically, the display is constructed in 30-ft long joints of about 28 ft of wired screen, although custom-designed lengths can be provided. Screens with a minimum of blank should be constructed because gravel vacuums are generated in locations where the gravel cannot be dehydrated. Running tools that minimize the amount of blankness required are available. These tools allow the screen to land on the neck instead of the blank beneath the necklace.[10]

3.3. Screen failure modes and causes

Sand screen completions, when correctly planned, installed, and applied, can provide many years of excellent sand control and protection from sanding in those sorts of wells. Downhole conditions are frequently unknown or change dramatically over time, and a sand screen completion may be subjected to pressures, abrasives, and unfavorable flow conditions for which it was not designed. This section discusses the most typical failures that can occur when screens are subjected to a variety of unfavorable environments and forces.

1. Erosion during pumping- Sand control screens can erode in oil and gas wells, resulting in catastrophic completion failures, significant production losses, and damage to downstream infrastructure. Several completion design and environmental conditions can contribute to screen deterioration. However, the most common cause of failure is the passage of tiny solids through the screen holes, which results in the formation of localized high-velocity hot spots in the screen filter media and eventual media collapse. Figure 12 shows a screen failure due to erosion during gravel pack pumping operations. In a short amount of time, a frack pack with a high rate may seriously damage a screen (less than one minute).

Figure 16. Screen failure-caused by erosion during pumping[10]

2. Incomplete Perforation Packing - A fracture occurs in a vertical plane parallel to the direction of greatest stress, which is also the path of least resistance. A fracture starting along the well bore in a deviated well will shift direction to locate the direction of least resistance if the well route is not parallel to the direction of highest stress. The greater the curve, the more divergence from the greatest stress direction and the greater the disparity between maximum and minimum stresses. Sharp twists cause tortuosity, which causes slurry flow resistance. It might also shorten the distance between the fracture and the well bore. As a result, the treatment pressure will rise, the proppant will have a harder time filling the fracture, and the ultimate fracture conductivity will drop. When a lengthy interval is fractured, the leak off increases, requiring a higher flow rate to meet the fracturing pressure. Furthermore, extended intervals increase the probability of permeability heterogeneity. The flow is driven toward the greatest permeability layer, which functions as a thief zone, after the fracture is opened. As a result, the slurry will quickly fill this high-permeability crack. All flow to lower zones is halted after the screen out is achieved in this zone, i.e. the proppant has packed the fracture and the screen to casing annulus, and they are left with little proppant in the fracture and annulus. Another challenge with long intervals is the greater danger of heterogeneous fracture pressure over the length of the interval. When the layer with the lowest fracturing pressure is at the top of the interval, it will be fractured and packed before the lower layers, which need more pressure, can be broken. The lowest section of the interval is left unfractured and unpacked once again. Figure 17 shows a screen failure due to insufficient perforation packing. The non-protected screen was blasted by formation sand during production.[10]

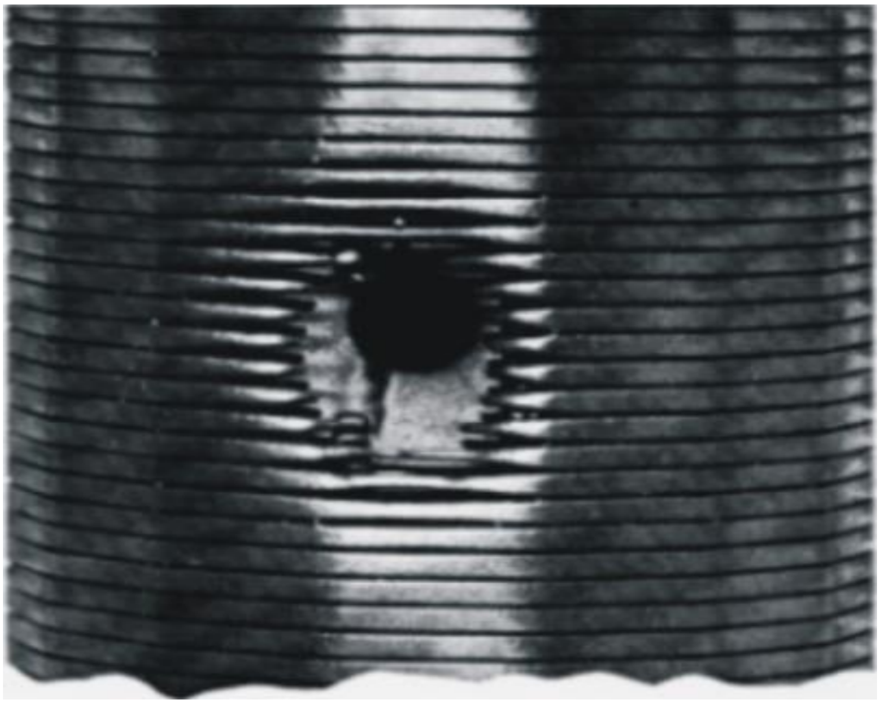


Figure 17. Screen failure -caused by incomplete perforation packing[10]

3. High Drawdown and Plugging- Figure 18 is an example of a screen failure caused by high drawdown pressures exerted on the screen in combination with screen plugging.

4. Mechanical fluid loss device not sealing or poor injection well filtration – Due to transient pressure and flow events, the generation of fines and matrix sand into the well bore is a prevalent concern in water injection wells. Conventional sand control systems do not properly manage these transitory events, and the sand control's reliability suffers as a result. A shutdown event in an injection well causes a rapid stopping of flow, resulting in a surge that can cause powerful downhole pressure transient effects such as back-flow, cross-flow, and water-hammer. These effects can cause sand particles in the near-wellbore to be mobilized, resulting in an influx of fine particles, screen plugging, and erosion. Eventually, debris build in the well can reduce or block injection rates to the point where a water injector well must be repaired or replaced in order to maintain the injection volumes required for reservoir pressure maintenance and sweep. Figure 19 shows an example of a screen failure caused by a mechanical fluid loss mechanism that did not seal or an injection well that was not properly filtered.[10]

Figure 18. Screen failure-caused by high drawdown and plugging[10]

Figure 19. Screen failure-caused by non-sealing mechanical fluid loss device or poor injection well filtrations[10]

5. Screen Tensile Failure – Using conventional testing equipment, tensile strength tests were conducted on screens and slotted liners, and the findings revealed that normal pipe-base screens have greater tensile ratings than rod-base screens. Testing revealed that yielding occurred in both the pipe body and the coupling, as indicated by the results of the tests. As a result, when a thread was separated as a result of a yielding in the connection, the test was terminated. It was discovered that the tensile strength of conventional pipe-base screens was approximately twice that of rod-base screens. To ensure that designs are conservative, the tensile strength should be equal to either 65 percent of the pipe body or the published joint pull-out strength. The screen failure caused by tension failure is depicted in Figure 20.

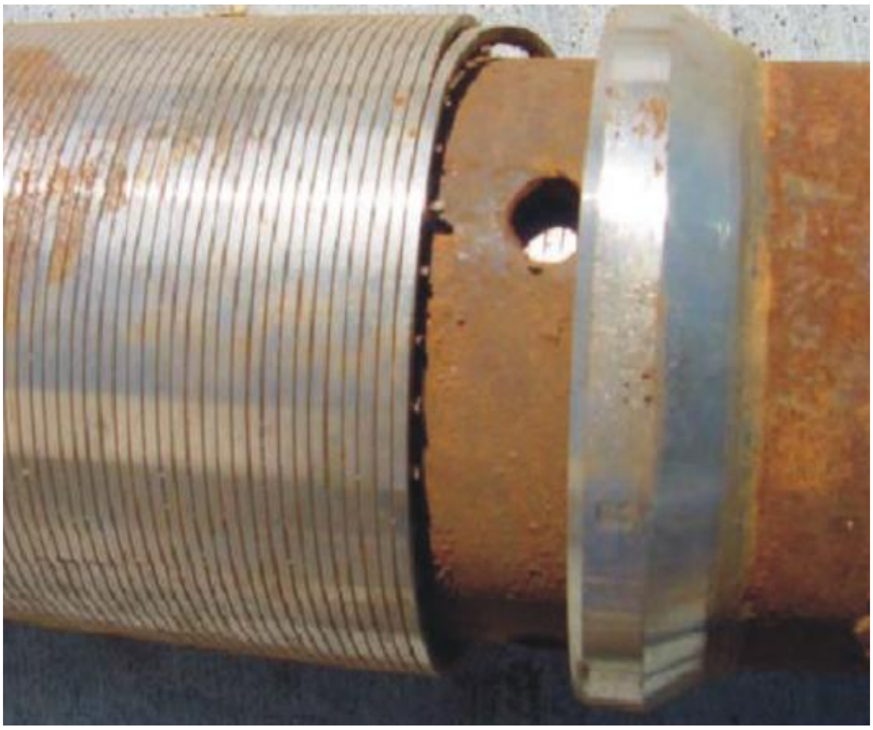


Figure 20. Screen failure-caused by tensile failure[10]

4. Case study: Field experience-West Absheron field

4.1. Field description

West Absheron is an oil field in Azerbaijan, located in the Caspian Sea from the north side of Absheron Peninsula (Figure 21). Now, it is operated by SOCAR. Field was discovered in 1985 and first production occurred in 1989. Water depth varies between 2-20 meters. Field dimensions are 11x4 km. The seabed where the field is located is covered with imported sand and shells and their clayey-sandy Pliocene sediments lie beneath. Cretaceous-age sedimentary complex, consisting of modern sediments at the intersection of West Absheron field, has been discovered and studied through wells. Modern sediments are composed of small and medium-grained quartz sands and shell limestones and could be up to 30 meters thick.

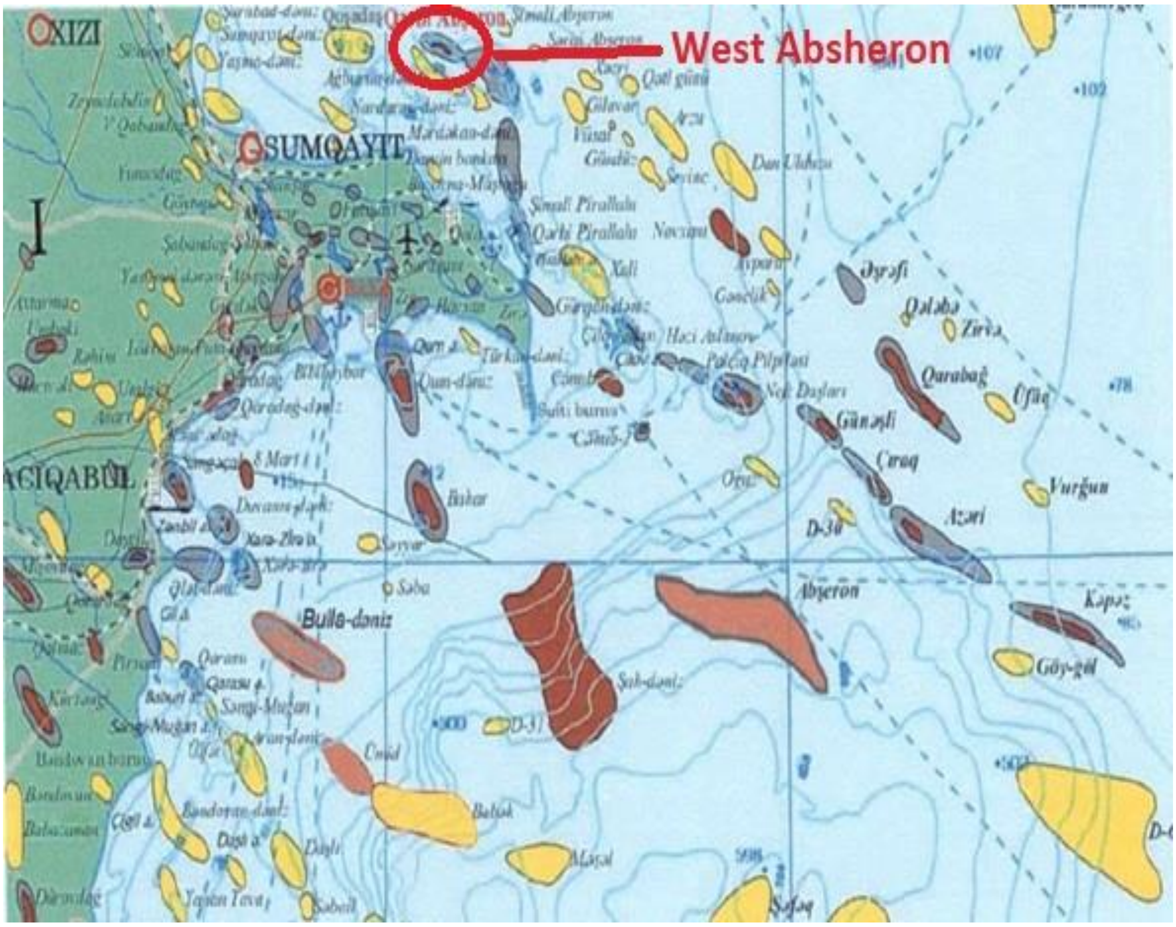


Figure 21. Location of West Absheron field

Productive Horizon (MQ)- as in the oil and gas fields of Absheron consists of different thickness of layers with sandy, siltstone, sandy-clay.

Balakhani Horizon- is spread over the entire area of the field. Lithologically, the group is sand, sandstone and the alternation of clays. The amount of sand is 60-70%, the layer thickness changes between 550-1000 meters.

Fasila Horizon- its sediments were discovered in all structural exploration wells and lithological thick sand, sandstone layers are composed of weak clay layers. Thickness changes between 80-100 meters.

Gırmakıustu Gilli Horizon (GUG) - mainly, its lithology consists of clayey lithofacies, to the deeper the amount of clayey decreasing. The thickness of layers changes between 70-90 meters and 100-115 meters on the top and wing sides, respectively. (flang)

Gırmakıustu Qumlu Horizon (GUQ) – lithology mainly consists of sandy lithofacies. Low thickness clay, small and medium-grained sandstones are observed. Thickness reaches 30-60 meters.

Gırmakı Horizon (GD) – contains a thin rhythmically alternating sand, siltstone-sand and various size of clays. The upper and middle part of the section is very clayey, to the deeper there are increasing sand and sandstone amount. Thickness varies between 200-280 meters.

Gırmakıaltı Horizon (GAD) – consists of medium-grained quartz sands and low thickness clay layers. In some wells, at the bottom of section high-visibility, electrically resistant layers are separated. The thickness reaches 90 meters.

Gala Horizon (GaLD) – its sediments were discovered in the distant wing of the fold and consist of alternating clay, sand and sandstones.

Currently there is 80 wells have been drilled and 50 of them produce. Daily oil production is 810 tonne. **GA, GD** are the productive horizons of West Absheron field. As of 01.01.2021, 495.8 thousand tonnes of oil was produced from GD horizon and 245.8 thousand tonnes from GA horizon. The total residual oil reserves of the GD horizon are 6750200 tonnes, and the dissolved gas reserves are 1133.8 million m^3. These numbers for the GA horizon are 4858200 tonnes and 875.3 million m^3 showing residual oil reserves and dissolved gas reserves, respectively.

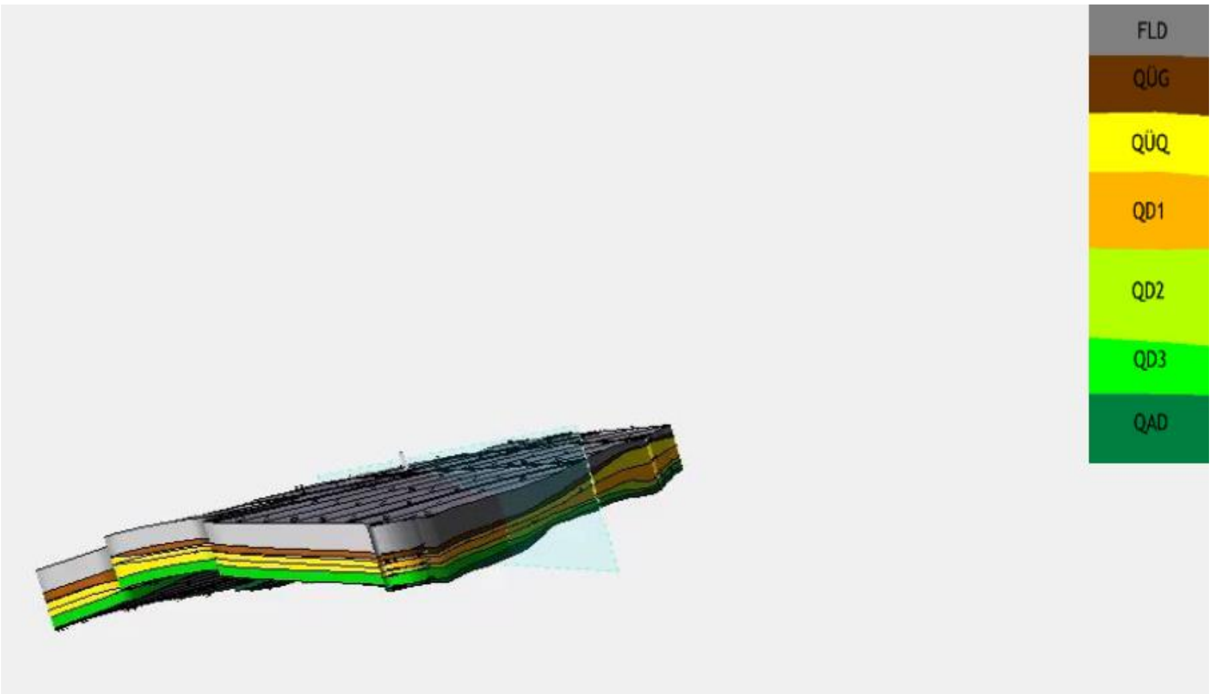


Figure 22. Geological model of West Absheron field

Figure 23 gives information about the production history of West Absheron field.

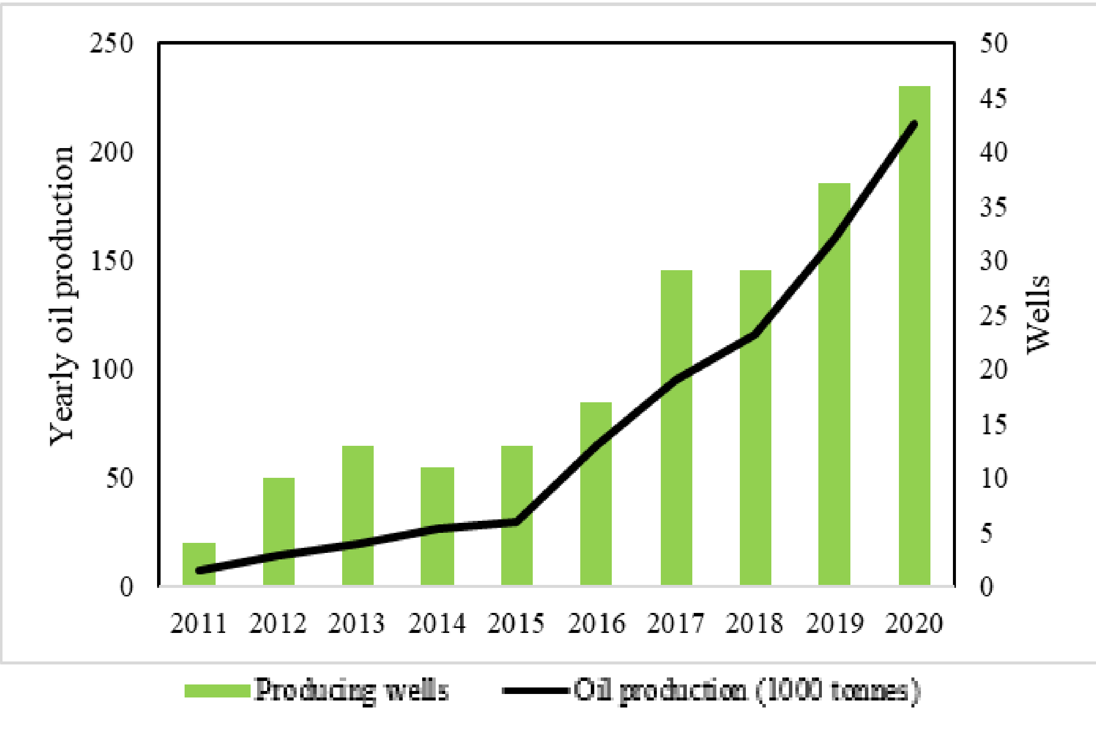


Figure 23. Production history of WA field[14]

4.2. Sand production and sand control method

As West Absheron is being producing over the years, depletion occurs and sand control mechanisms should be properly designed to achieve desirable outcomes. All target formations are weakly consolidated with low unconfined compressive strength and sands are non-uniform based on the laser particle analysis. Reservoir pressure changes around 1000-1200 psi. Therefore, both injection and production wells require downhole sand control. Sand control actually is very challenging in West Absheron due to highly depleted reservoirs, poorly sorted sand and also high drawdown comparing to the standard completion in industry.

Well A is an example of well which produce sand. well A that is completed with the two main intentions which are producing of residual resources and reducing the rate of decline in production in the upcoming years. Main wellbore was drilled to a depth of 828 m with 265○azimuth to the GA horizon and sidetracked wellbore was drilled to the depth of 713 m with a deviation of 240○azimuth. For the GA horizon screens were put in the depth of 772-662 m (110 m) and for the GD horizon screens were placed in the depth of 692-630 m (62 m). Figure 24 illustrates the trajectory of well A.

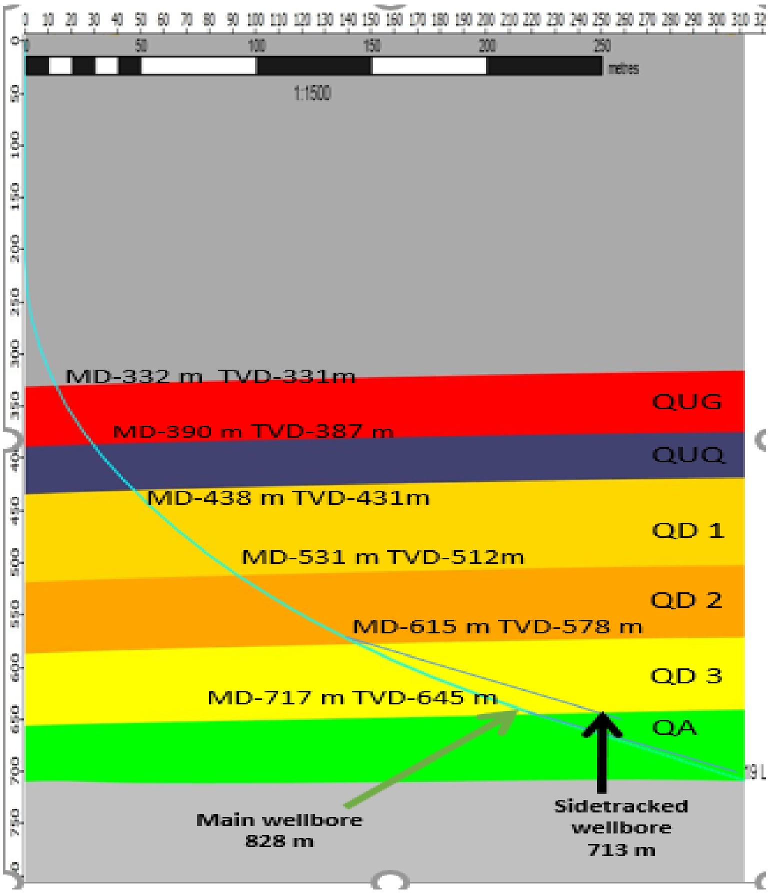


Figure 24. Trajectory of well A

During the preparation of the project of well A, 7 different options were analyzed. Of these options, multi-lateral well drilling and completion of the main wellbore from the QA horizon and the sidetracked wellbore from the QD horizon were found to be more efficient. It is indicated in solid red line in the figure 25.

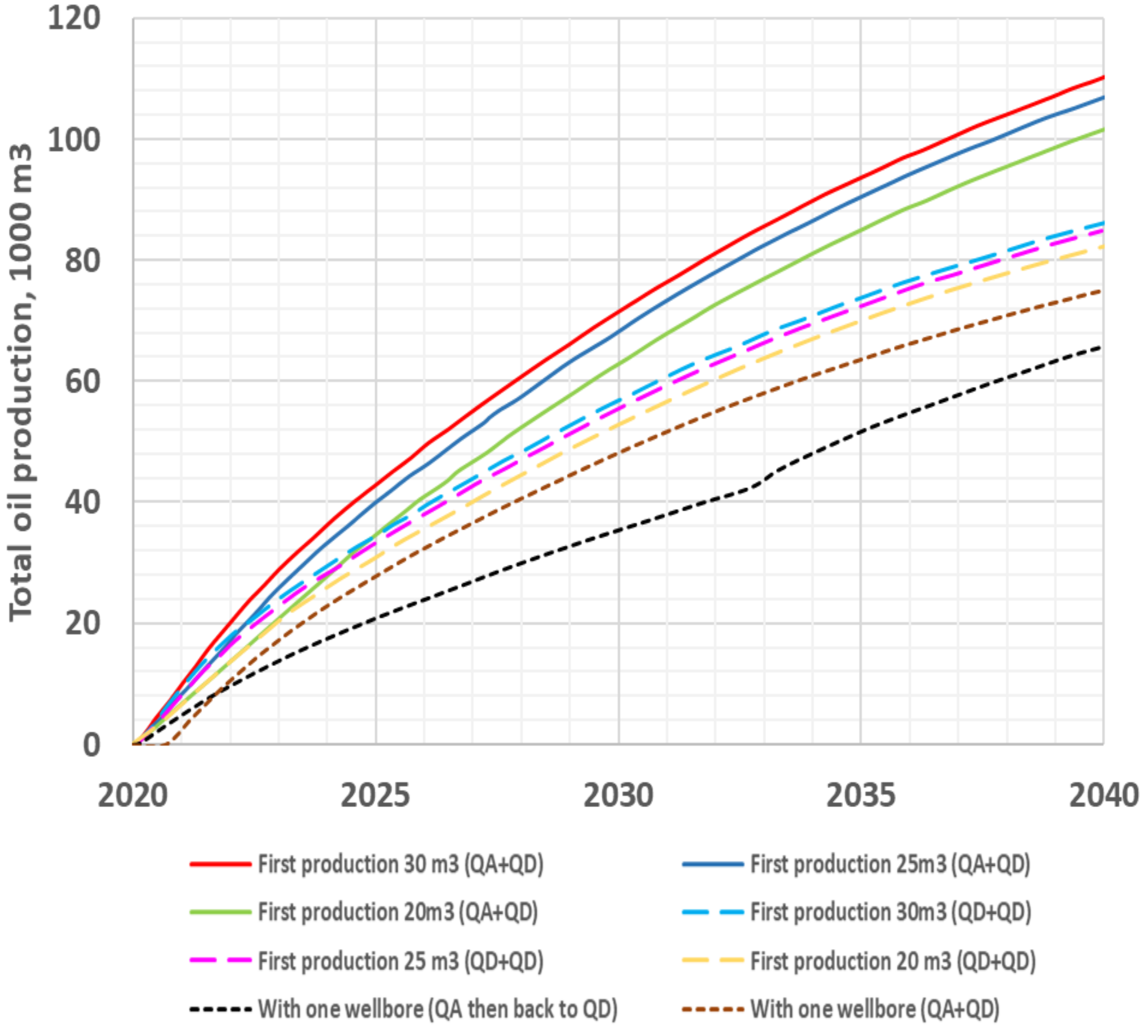


Figure 25. Total oil production based on horizons[14]

Before choosing completion method there are some records of wellbore were made. As it is seen from the correlation (Figure 26) comparing to Well B it is obvious that Well A main and sidetracked interval produce sand. And Figure 27 shows the sand percentage of the horizons accordingly.

Well B **Well A (sidetracked wellbore)** **Well A (main wellbore)**

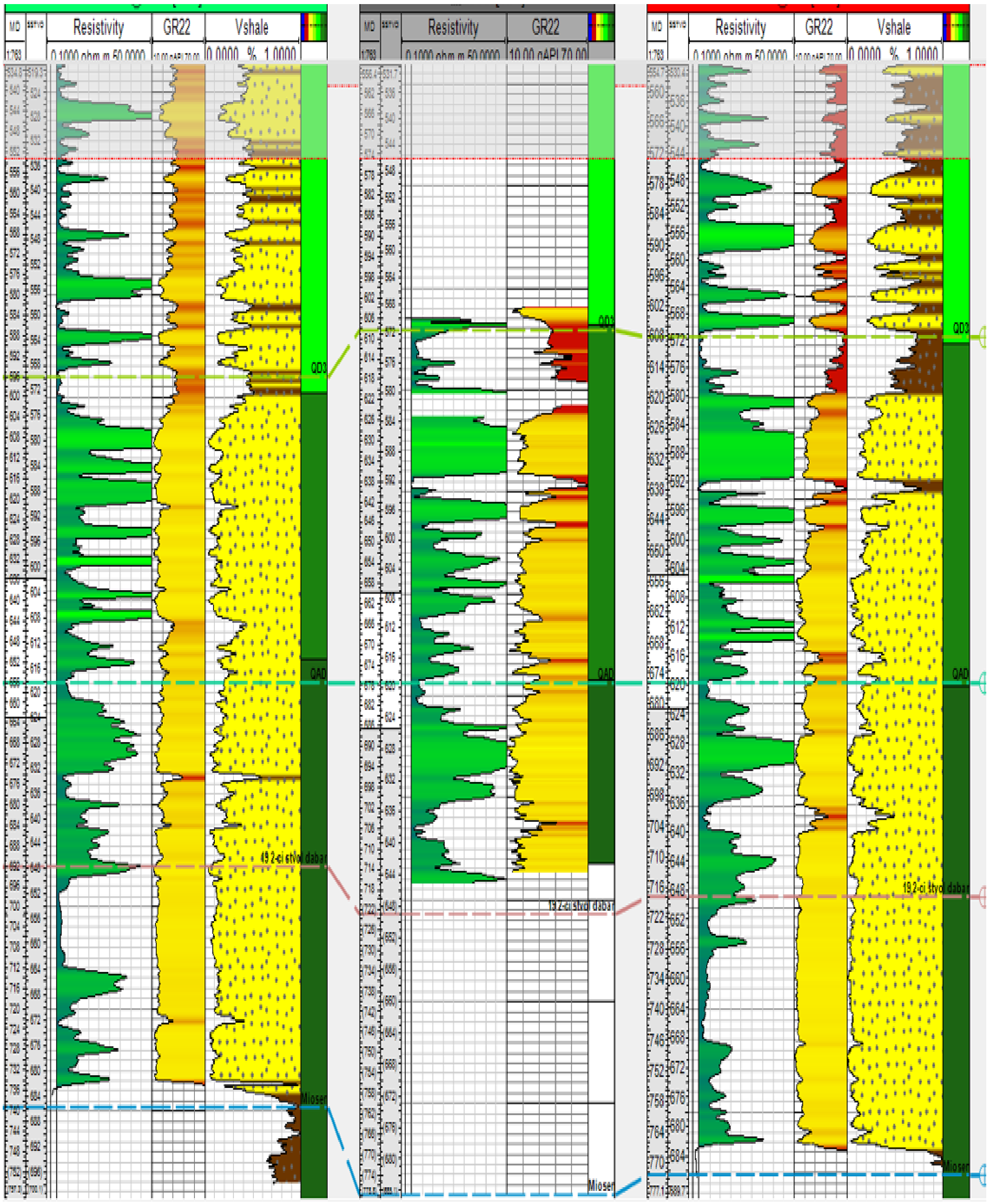


Figure 26. Correlation (comparing to Well B)

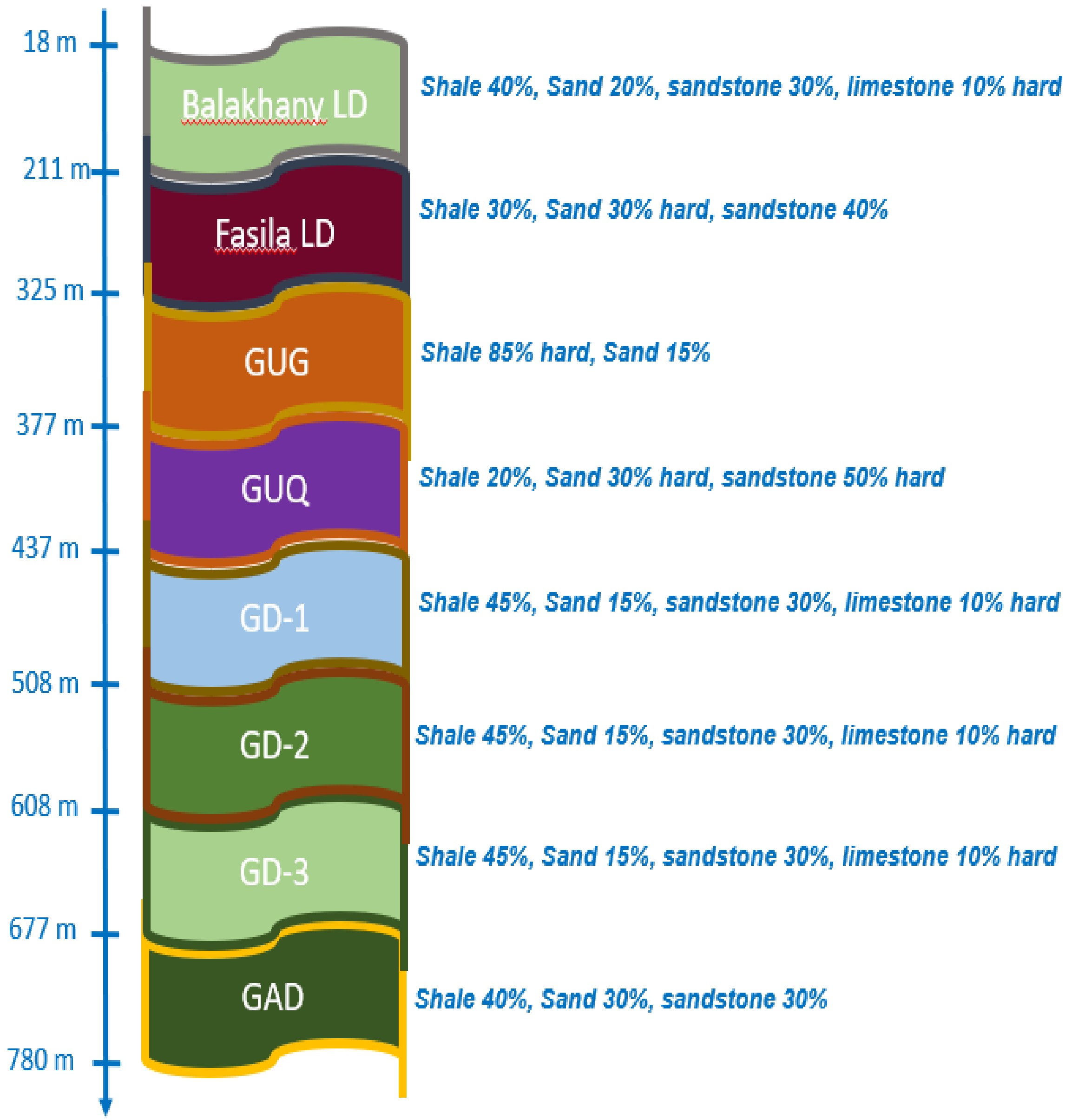


Figure 27. Stratigraphic distribution and lithology

4.3. Screen installation

It is the goal of sand control management to prevent potentially damaging formation sand from entering the wellbore while also limiting fluid flow restriction. In general, it is preferable to allow harmless, migratory fines to develop rather of having them fill the near wellbore region, which would result in significant flow restriction over time. The premium wire-mesh screen sets the industry standard for resistance to clogging and erosion and for production life. Its protective vector shroud is suited for extended horizontal, open hole, standalone, and gravel-pack applications.

This type of screen is a sand exclusion downhole sand exclusion device that integrates the industry renowned EXCLUDER™ screen sand retention and durability technology with greater mechanical strength and integrity (Figure 28).The EXCLUDER2000 utilises a revolutionary manufacturing process enabling the different components to operate as one, providing a stronger more lasting product. Additionally, a more durable filtration membrane junction and cartridge seal design has been introduced. The EXCLUDER2000 screen's revised design has boosted its previously proven ability to function in the most severe conditions like open hole horizontals, short radius wells, re-entry, and gives enhanced protection for any gravel pack/frack pack situation. [11]

During sand analysis it is found that more than 50 % of the particles were less than 200 microns in size. Because of this 225 microns size screens were installed in Well A.

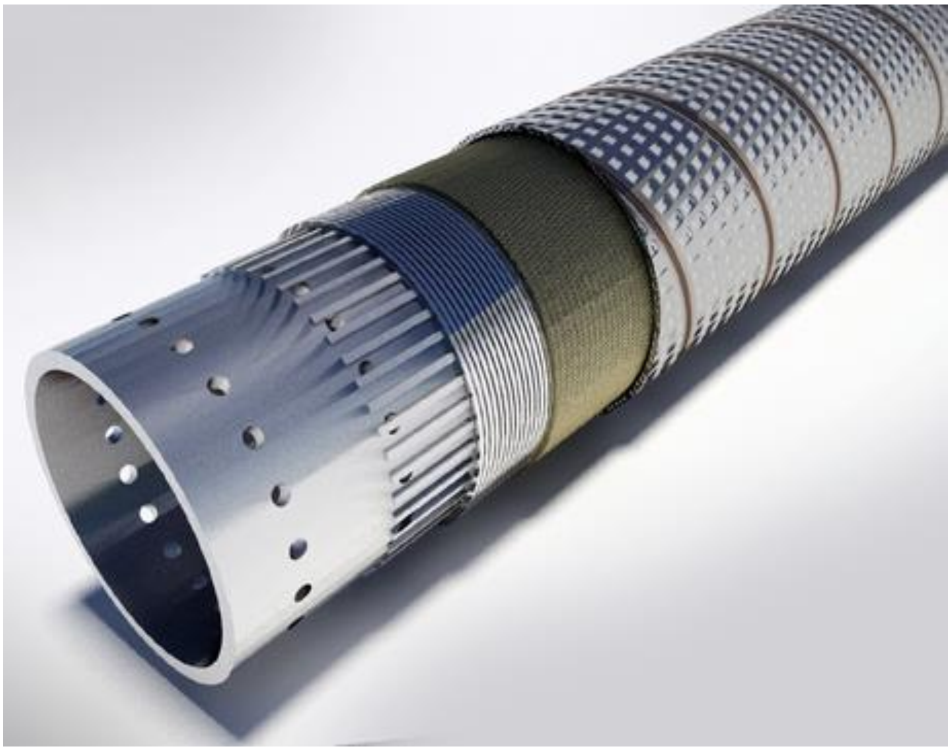
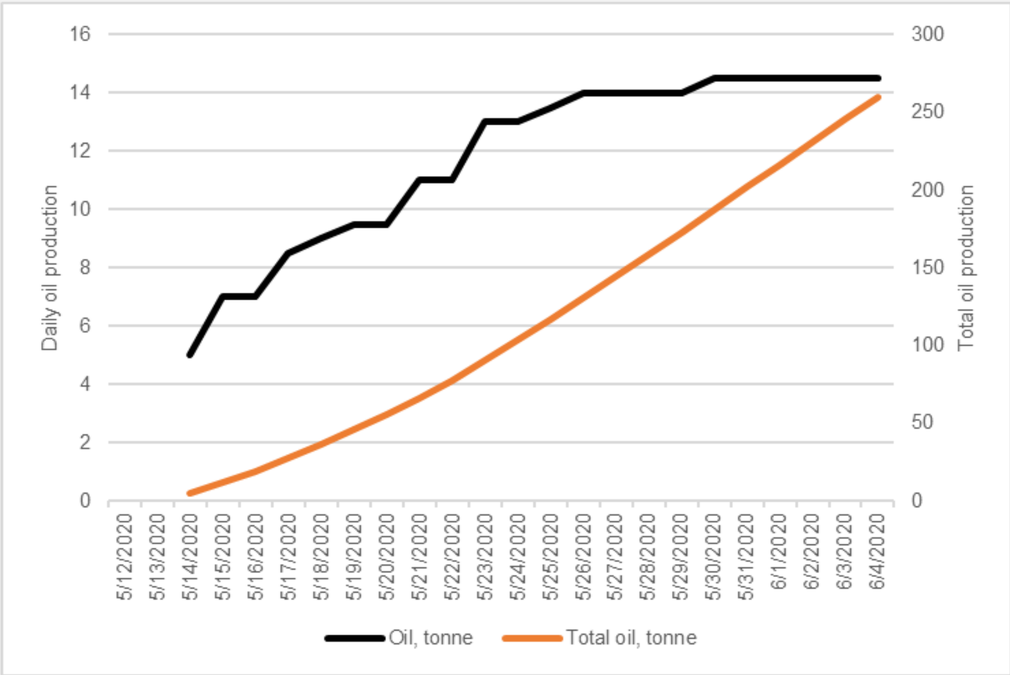
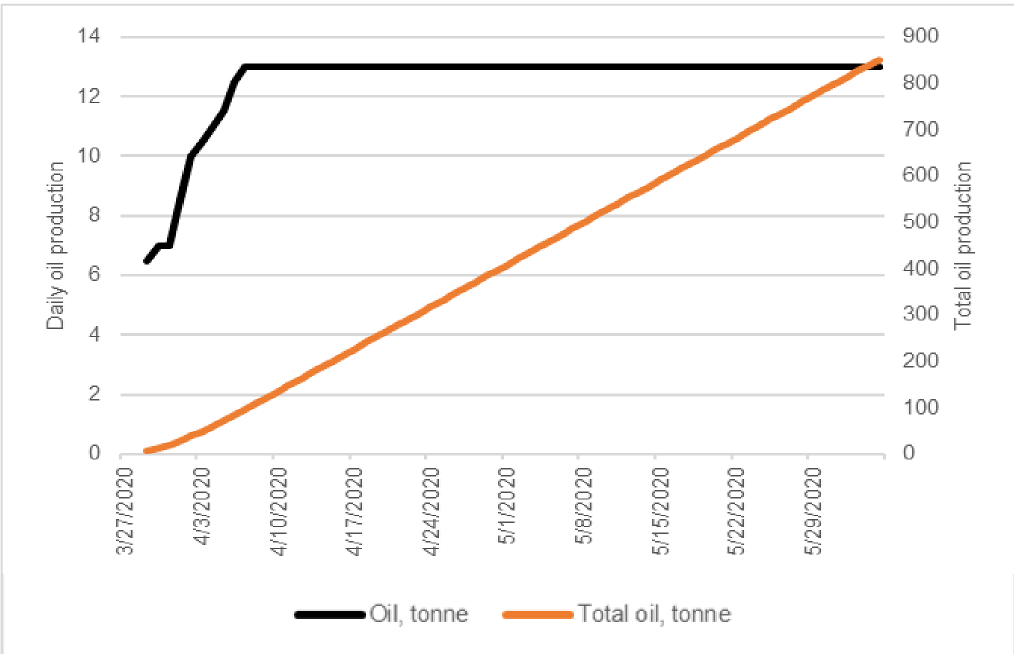


Figure 28. Premium wire-mesh screen [11]

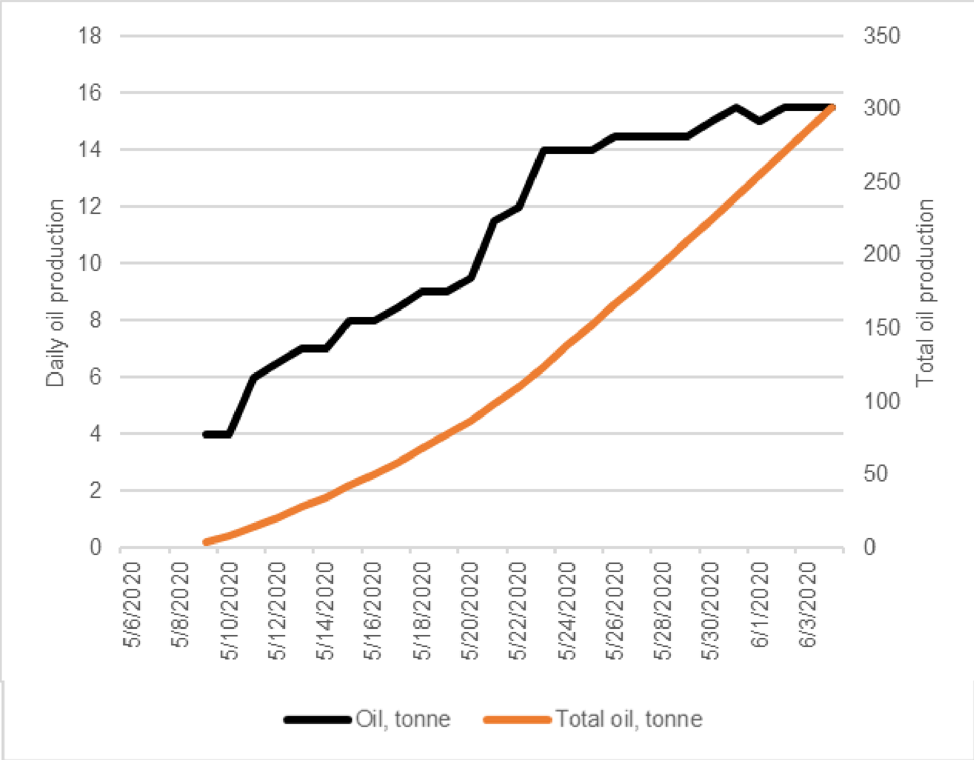
Installation of standalone screens gave positive effect on the other wells in West Absheron Field. Figure 29 shows the production history of wells which have been completed with Direct Wire Wrap Screens. (see 3.1)



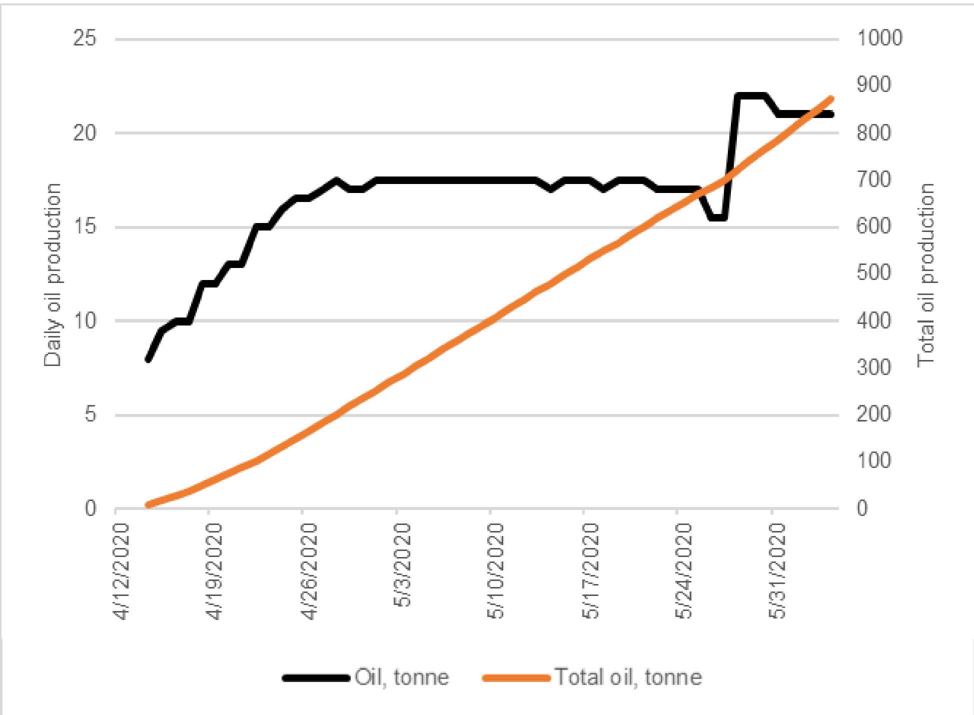
Well C



Well D



Well E



Well F

Figure 29. Production history of screen-completed wells

Conclusion

To conclude, sand screen and mainly stand-alone screens are widely applied and reliable sand controlling technique in depleted reservoirs. They can bring numerous advantages and beneficial for low-cost completion in depleted reservoirs. Despite the fact that, sand screening is technically challenging and productivity impairment may be observed, however, proper designing of completion schematic and selection of the screen can provide satisfactory outcomes. Throughout the research, sand production causes, confirmation and monitoring of sand production, sand control methods, and consequences are fully researched and explained. Furthermore, design considerations, selection and operation of the sand screens completion and application of the stand-alone screens to the sand produced reservoirs were discussed.

All mentioned factors were discussed throughout the research, and finally real field examples were considered in order to observe theoretical trends on the practical example. In West Absheron field, wells were completed in a simple way without using any sand control method in the past. Afterwards, due to mentioned problems above, standalone screens become much preferable completion option in the sand producer wells. Standalone screens have been successfully applied in the last 3-4 years with ESPs (electrical submersible pump). From the results of the comparative analysis, it was determined that the drilling of multi-lateral wells and completing sand producing intervals with new types of screens are more efficient for the development of West Absheron field. In this regard, it is proposed to drill this type of wells from existing and future wells and complete sand producing intervals with mentioned screens.

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