

QUESTIONS & ANSWERS FOR APOLLO GREENZYME®**A BIOLOGICAL ENZYME & ITS APPLICATIONS IN OILFIELDS.**

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Q1: What is Apollo GreenZyme®?

A1: Apollo **GreenZyme®** is a biological liquid enzyme, developed and trademarked exclusively by Apollo Separation Technologies Inc. of Houston, Texas.

GreenZyme® is the first biological enzyme ever used in enhanced oil recovery in the world since 1990s, namely **E-EOR** (i.e. Enzyme-Enhanced Oil recovery).

One of the main uses for Apollo **GreenZyme®** is for enhancement of crude oil recovery from most oil wells, both onshore and offshore.

Q2: How long has Apollo Separation Technologies Inc. been in business in Houston?

A2: We are continuously in business since 1990.

Q3: What is a biological liquid enzyme?

A3: A biological liquid enzyme is a protein-based non-living catalyst, which facilitates the completion of biological reactions.

Q4: Is Apollo GreenZyme® similar to any other living microbe's method?

A4: The answer is no.

Apollo **GreenZyme®** contains non-living enzymes derived from living microbes. However, an enzyme is completely different from a microbe. Similarly speaking, a chicken egg is derived from a living chicken, but an egg is not a living chicken.

Enhanced Oil Recovery process using Apollo **GreenZyme®** versus using living microbes are two completely different processes. They are not the same.

Q5: How is Apollo GreenZyme® produced?

A5: Apollo **GreenZyme®** is produced by a proprietary process, which involves impregnating a high protein nutrient soup with the DNA of selectively cultured microbes. The final product contains enzymes associated with oil-eating microbe's

DNA. Nearly all-living microbes are made inert at the end of the manufacturing process. Apollo Separation Technologies Inc. currently manufactures more than 10 formulas of our **GreenZyme®** family, which can be used for different applications.

Q6: What is CAS number for Apollo GreenZyme®?

A6: CAS number is assigned to known chemicals only, CAS number do not applied to any biological materials with DNA. For this reason, there is no CAS number for **Apollo GreenZyme®**, just like there is no CAS number for a chicken egg.

Q7: How safe is Apollo GreenZyme®?

A7: Under normal applications, Apollo **GreenZyme®** is totally harmless to any individual's health, as well as to the environment. All formulas of Apollo **GreenZyme®** are: near neutral in pH during injections; pH varies anywhere from 5 to 7; non-pathogenic; biodegradable; and environmentally friendly.

Please refer to our Manufacturer's Safety Data Sheet (MSDS) for proper handling of **GreenZyme®** products.

Q8: How does Apollo GreenZyme® increase crude oil production in most oilfields?

A8: When injected into oil-bearing sand formation of any oilfield, Apollo **GreenZyme®** can instantly and quickly release hydrocarbon oil from the surface of these sands in a catalytic fashion, changing the nature of these sands from either oil-wetted surface or water-wetted surface to non-stationary **GreenZyme®** protected water-wetted surface (i.e. GPWW surface).

GreenZyme® does not cause any chemical reactions. Unlike chemical or polymer additives, when these additives encounter paraffins, asphaltenes, ground water and other clogging problems inside the sand formation, these chemicals can quickly weaken and diminish themselves in strength and effectiveness by their own complex chemical reactions.

Apollo **GreenZyme®**, being a catalyst however, does not diminish or weaken itself when encountered with the same problems. Since Apollo **GreenZyme®** is biological in nature, it performs only its biological duty to release-crude-oil, even in the presence of large quantities of ground water and other solid causing-and-clogging problems like paraffins and asphaltenes.

Since Apollo **GreenZyme®** is insoluble in crude oil and soluble only in water, the **GreenZyme®** proteins can be carried by formation-water to deeper regions of the

surrounding formations through pressure-induced diffusivity and concentration-gradient-differential diffusivity, (i.e. due to pressure differentials, osmotic and diffusional forces at work etc), opening more new flow-channels and creating new fingerings-of-flow within the sand-formation for months and years to come.

All our past successful stories indicated that Apollo **GreenZyme®** is capable of releasing more of the so called non-recoverable crude oil from the oil-bearing sands than previously thought possible.

Q9: Under what conditions should I use Apollo GreenZyme® to enhanced oil recovery (i.e. E-EOR) in my oilfield?

A9: The best conditions to apply Apollo **GreenZyme®** to your oilfield are as follow:

- a) An old well suddenly shows rapidly decreasing crude oil production; a sign showing formation of positive-skins; some formation-clogging problems or slight rising water-coning problems.
- b) A new well that produces very little total-fluid-flow since from day-one.
- c) A relatively young well begins to encounter increasing water production problems.
- d) Highly desirable to use **GreenZyme®** before: water-flooding wells; chemical fracturing wells; steam injection wells; thermal and heat-burning-and-treatment wells; bore-head and other major repairing wells.

Typical candidate oil well for **GreenZyme®** varies greatly, an ideal one is as follow:

- 1) Initial oil production when new > 100 BOPD, the higher number the better.
- 2) Current oil production > 15 BOPD.
- 3) Water cut < 75 % water.
- 4) Porosity > 15%, with sufficient formation pressure.
- 5) Piping integrity and pump are in good working condition.

Of course, **GreenZyme®** also works for other lesser ideal oil wells too.

Note: Apollo **GreenZyme®** should not be used on dead oil wells, or very low and marginal producing oil wells, i.e. those producing less than 10 BOPD oil wells, because even if **GreenZyme®** application is successful, the net oil gained may be non-economical and non-attractive in profit returns.

Q10: What other areas is good for Apollo GreenZyme® in my oil field?

A10: Apollo **GreenZyme®** is very effective when simultaneously applied to a localized oilfield consisting of more than 2 wells for small and big water-flooding projects.

For example: in a local oilfield consisting of 10 wells, use 7 wells out of the 10, which have the least positive-skins as the crude oil producers, and then use the remaining 3 wells as the injection wells.

If injecting both the produced-water and **GreenZyme®** into this formation, namely as the driving force, will flood and pressurize the formation with good results.

In this water-flooding method, the crude-oil freed by **GreenZyme®** within the formation can be easily driven towards the 7 target-production wells. In this way, we can water-flood the oil-bearing formation to recover the crude oil released by **GreenZyme®** within the sandy formation, which will maximize the total oil recovery. This Apollo **GreenZyme®** enhancement method can achieve a much higher crude oil production rate than most experts previously thought impossible.

Similarly, for those oil wells that need steam-stripping, chemical treatment or fracturing works, Apollo **GreenZyme®** can be used alone or in conjunction with any one of these applications, usually with astounding results.

Q11: Is there any other requirements needed for GreenZyme® applications?

A11: Before you consider using **GreenZyme®** in an oil well, you will need to be sure both the tubing and the casing integrity are in excellent working condition.

You need to be sure the target oil well does have a measurable Static Liquid Level (i.e. SLL) inside the tubing section of the oil well.

If there is a pour-point temperature problem for the crude oil, make sure the formation temperature is at least 20 degrees centigrade higher than the pour-point temperature of the crude oil, with proper insulation protection of all piping.

For example: If the crude oil pour-point temperature is 35 degrees C, and the sand-formation temperature is 65 degrees C, then you are good for **GreenZyme®**.

Note: If the temperature difference in the above example is less than 20 degree C, please do not use **GreenZyme®** in this well, because even if a lot of crude oil is released by **GreenZyme®** in the underground formation, this oil may be running into a frozen stage, and eventually may be too difficult to be push-up through the tubing-side to ground level.

If the crude oil produced from your oil well at ground level is pour-able at ambient temperature, even in the coldest month of the year, then this oil well is acceptable for **GreenZyme®** applications.

Q12: Do we need to worry about formation complexities like pH, high salinity, presence of heavy metals, high wax content and high temperature conditions when using GreenZyme® in our oil wells?

A12: Since **GreenZyme®** is a DNA-based non-living biological catalyst, **GreenZyme®** has no chemical reactions with most complexities found in the formation.

Please notice that, you **do not** need to worry about the following conditions:

- a) pH of the fluid in the sand-formation.
- b) Salinity of the fluid in the sand-formation.
- c) Temperature in the sand-formation because, in laboratory tests, **GreenZyme®** under pressure does not degrade and perform very good at testing temperatures of 270 degrees C. **GreenZyme®** perform very well for steam-huff-and-puff applications under pressure at 450 degrees centigrade.
- d) Presence of any metallic ions in the sand-formation; since **GreenZyme®** is a biological agent, not a chemical agent, **GreenZyme®** does not react with most natural chemical agents present inside typical sand-formations.
- e) Presence of paraffins, naphthatenes, asphaltenes or sulfur at any percentage.
- f) Any radio-active isotopes (i.e. NORM) in the crude oil.

Q13: What equipment do we need to inject GreenZyme® in my oil well?

A13: You will need the following equipment:

- a) One high pressure pump, capable of up to 5,000 PSI pressure, if possible.
- b) One large, mobile mixing tank for diluting **GreenZyme®**.
- c) Saline water (i.e. local produced water) for **GreenZyme®** dilution and capping.

Q14: Which side to inject GreenZyme®? Cashing-side or Tubing-side piping?

A14: In any kind of oil well, **GreenZyme®** is usually injected into the targeted formation or pay zone through the casing-side; this is a simpler and cheaper process.

If you must inject **GreenZyme®** through the tubing-side of the oil well, you need to remove the packer first before **GreenZyme®** injection.

Q15: What are the three common types of oil wells in any production oilfield?

A15: In any oilfield, you will likely encounter three common types of oil wells, identified and based only on the current formation pressure, namely:

- a) Sufficient formation-pressure oil well. (i.e. **SFOW** > **0.265 psi/ft**).
- b) Insufficient formation-pressure oil well. (i.e. **IFOW** < **0.265 psi/ft**).
- c) Broken formation pocket-well. (i.e. **BFPW** <= **0.05 psi/ft**).

Q16: What are the characteristic of these three common types of oil wells?

A16: **SFOW**: Sufficient Formation-pressure Oil Well has two characteristics, namely:

- a) An oil well still shows good remaining formation pressure, i.e. formation pressure greater than six mega-pascals per thousand meters of depth. (i.e. 6+ MPa/ 1000 meter well depth).
- b) Active formation water near the perforation area, i.e. active and sufficient bottom water or peripheral water to replenish total daily fluid production.

IFOW: Insufficient Formation-pressure Oil Well has two characteristics, namely:

- a) An oil well shows less remaining formation pressure, i.e. formation pressure less than six mega-pascals per thousand meters of depth. (i.e. under 6 MPa/1000 meter well depth).
- b) Inactive formation water near the perforation area, i.e. little and insufficient bottom water or peripheral water to replenish total daily fluid production.

BFPW: Broken Formation Pocket-Well has three characteristics, namely:

- a) An oil well shows rapid decline of formation pressure in a short production period of time. For example: in less than a year or two, the remaining formation pressure rapidly approaches one mega-pascals per thousand meters of depth or lower. (i.e. 1 MPa/ 1000 meter well depth).
- b) Oil-water cut ratio is nearly 100% oil with very little water.
- c) Near zero formation water in the vicinity of the perforation area, i.e. total lack of active bottom water or peripheral water to replenish total daily fluid production.

Q17: Can Apollo GreenZyme® be used effectively on all of these three common types of oil wells?

A17: Yes, Apollo **GreenZyme®** can be effectively applied to all three types of oil wells commonly found in a producing oilfield, namely: **SFOW**, **IFOW** and **BFPW**.

However due to formation pressure differences, each of these oil well types will require a different injection process and varied dilution strength of **GreenZyme®** when applied properly.

The overall success rate and crude oil enhancement results of each type will also vary. We will discuss these in detail below.

Q18: Can GreenZyme® be applied to both sand-stone formation and lime-stone formation oil wells?

A18: Yes, **GreenZyme®** can be used in both types of formations. For sand-stone formation oil well, using only **GreenZyme®** injection alone is sufficed.

However, only for lime-stone formation oil well, beside **GreenZyme®** injection, depending on the total depth of well and total daily fluid production, we also need to inject some quantity of dilute acid, (e.g. 1-3% HCl) either before or after **GreenZyme®** injection.

Q19: How do we start injecting GreenZyme® into my oil well?

A19: If you have identified a good candidate oil well for **GreenZyme®** application, then you need to decide which type of the three common types of oil wells is yours, according to the classification defined in question number 15 above, and then proceed as follow:

For SFOW type wells, i.e. Sufficient Formation-pressure Oil Well:

- a) Use a mixing tank, mix the right quantity of 100% **GreenZyme®** with produced water to make a 5% to 10% range of dilute **GreenZyme®** solution, then inject/pump-down this dilute solution into the formation, the injection rate is not critical, usually the injection rate of about 50 gallons per minute will do.

The total volume of diluted **GreenZyme®** depends on the depth of the oil-bearing sands, i.e. oil thickness pay zone. In general, this volume is about 3 metric tons per meter depth of pay zone, i.e. 3 mt/meter.

Please refer to the question 20 below for the suggested quantity of **GreenZyme®** needed for each oil well.

- b) Inject one full tubing (or annulus casing) volume of produce water or more into the oil well as capping fluid, and hold the time required for capping (i.e. resting time) before reopening this wellhead using typical oil production procedures.

Please refer to question 24 for the capping time needed after injecting all fluids.

Under normal conditions, the injection process for most oil wells can be finished in five to ten hours of time, depending on well depth and pay zone depth.

Hint: Most successful practice is to divide the total diluted **GreenZyme®** solution into two parts. Inject the first half of **GreenZyme®**, and then follow with a substantial quantity of produce water, and then inject the second portion of **GreenZyme®**, followed again by produce water, including the capping fluid.

Comment: the estimated EOR (i.e. enhanced oil rate) success rate of this type of operation is quite high, usually in the high 90+%, with total fluid production very often doubled or more. The average oil production increase often lasts more than an 18 months to three years, on some wells, even more.

For IFOW type wells, i.e. Insufficient Formation-pressure Oil Well:

- a) Use a mixing tank, mix the suggested quantity of 100% **GreenZyme®** with produced water to make a 2% to 4% range of diluted **GreenZyme®** solution, then inject/pump-down this dilute solution into the formation, the injection rate is not critical, usually at about 50 gallons per minute rate will do.

Your total injection volume of dilute **GreenZyme®** solution depends on the depth of the oil-bearing sands, i.e. oil thickness pay zone.

In general, this volume is about 30 metric tons per meter depth of pay zone, i.e. 30 mt/meter.

Please refer to question 20 for the right suggested quantity of **GreenZyme®** needed for each oil well.

- b) Inject one full tubing (or annulus casing) volume of produce water or more into the oil well as capping fluid. Keep the well shut-in for the time required (i.e. resting time) before opening-up this wellhead for regular oil production.

Please refer to question 24 for the shut-in time needed after injecting all fluids.

Under normal operations, the pumping process for most oil wells can be finished from eight hours to a day of time, depending on well depth and pay zone depth.

Comment: the estimated EOR (i.e. enhanced oil rate) success rate of this type operation is quite high, usually in the mid 80% range.

Total fluid production often increase significantly, and the average oil production increase often lasts over 12 -18 months, even without using a

nearby water injection well; if a nearby water injection well is available and used properly, the average oil production increase often lasts over a year to three years.

Hint: one good practice is to divide the total diluted **GreenZyme®** into two parts, inject the first part of **GreenZyme®**, then follow by produce water, and then inject the second portion of **GreenZyme®**, followed again by produce water, including the capping fluid.

Critical comment: for maximum oil recovery and full utilization of the Apollo **GreenZyme®** application, select an oil well with a nearby water injection well.

For BFPW type well, i.e. Broken Formation Pocket-Well type oil well:

- a) Use a mixing tank, mix the suggested quantity of 100% **GreenZyme®** with produced water to make a 1% to 2% dilution of **GreenZyme®** solution, then inject/pump-down 50% of this dilute solution into the formation, the injection rate is not critical, usually at about 50 gallons per minute rate will do.
- b) Next, verify the depth of your oil-pay-zone. Use only produced water. Inject 60 to 80 metric tons of produced water per meter depth of oil-pay-zone, i.e. 60 mt/meter to 80 mt/meter depth, into your oil-pay-zone.
- c) Finish injecting the remaining 50% of dilute **GreenZyme®** solution into the oil-pay-zone/formation.

Total injection volume of both the dilute **GreenZyme®** solution and produced water depends on the depth of the oil-bearing sands, i.e. oil thickness pay zone. In general, this volume is about 100 metric tons per meter depth of pay zone.

Please refer to question 20 for the suggested quantity of **GreenZyme®** needed.

- d) Inject one full tubing (or annulus casing) volume of produce water or more into the oil well as capping fluid. Maintain the well shut-in time needed (i.e. resting time) before opening-up this wellhead for regular oil production.

Please refer to question 24 for the shut-in time needed after injecting all fluids.

Under normal operations, the complete injection process for most oil well can be finished in one to two days, depending on well depth and pay zone depth.

Hint: One good practice is to divide the total diluted **GreenZyme®** into two parts, inject the first part of **GreenZyme®**, then follow by more produce water, and then the second portion of **GreenZyme®**, follow again by more produce water, including the capping fluid.

Comment: The estimated EOR (i.e. enhanced oil rate) success rate of this type operation is quite high, usually in the 90% range. Total fluid production increases quite significantly. Average oil increase often lasts over a year.

Critical comment: this type of well will need continuous and repeated applications of Apollo **GreenZyme®** , when you see total daily fluid production falls back to pre-treatment production levels.

Table summary:

Type of oil well	GreenZyme® strength %	Total volume of GreenZyme® and produce water usage per meter of pay zone (i.e. T _o)
SFOW: Sufficient Formation- pressure Oil Well.	5% to 10%	3 metric ton / meter depth (Approximate)
IFOW: Insufficient Formation-Pressure Oil Well.	2% to 4%	30 metric ton / meter depth (Approximate)
BFPW: Broken Formation Pocket-Well.	1% to 2%	100 metric ton / meter depth (Approximate)

Q20: What volume of GreenZyme® do we need to inject for an oil well?

A20: The right volume of **GreenZyme®** injection depends mainly on pay zone (i.e. T_o) in the sand-formation. See table as suggested guidelines for your candidate oil well:

a) For onshore oil well:

Thickness-of-oil in the	Quantity of GreenZyme®	Quantity of GreenZyme®
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sand-formation. T_o in meters (M)	requires, under more favorable conditions, in drums. (100%, 55-gallons)	requires, under less favorable conditions in drums. (100%, 55-Gallons)
$T_o < 10$ M	4 Drums	5 Drums
$10 < T_o < 20$ M	6 Drums	8 Drums
$20 < T_o < 30$ M	8 Drums	10 Drums
$T_o > 30$ M	10 Drums	12 Drums

b) For Horizontal oil well:

$T_o < 500$ M	8 Drums	10 Drums
$T_o > 500$ M	10 Drums	12 Drums

c) For offshore oil well: need consultation, typically similar to horizontal oil well.

$T_o < 1000$ M	14 Drums	16 Drums
$T_o > 1000$ M	18 Drums	20 Drums

d) For water-flooding drive oilfield: use **GreenZyme®** 250 ppm to 500 ppm range, also utilize the formation as a giant mixing tank underground, no above ground mixing is needed in this case.

Note:

- a) Favorable conditions are: oil density < 0.85; Porosity > 20%; Pour point temperature of oil is fluid at most ambient temperatures; underground formation is mostly oil-bearing sand.

Unfavorable conditions are: oil density > 0.90; Porosity < 10%; Pour point temperature of oil can be a problem at some ambient temperatures; underground formation is mostly oil-bearing limestone.

If your oil well has conditions in-between the above favorable conditions and unfavorable conditions, use your own judgment and use quantities of **GreenZyme®** between the two numbers in the above table.

- b) If the history of your oil well had many previous production problems, particularly if this oil well had been repeatedly treated with acid jobs, fracturing jobs, sand control jobs or gas-capping jobs in the past. You may need to consider using a minimum of **one drum of GreenZyme® per two meter of thickness-of-oil in the sand-formation.**

Q21: I have a problem, my oil well has 10 different pay zones, and all through only one-continuous-production-tubing, the total oil-thickness is over 100 meters. How much GreenZyme® do I need for this application?

A21: Since in this well, oil is not producing from only one targeted pay-zone, but producing from an open perforation of all 10 pay zones of over 100-meters; we do not want to waste a high number of drums of **GreenZyme®** to all 100-meters plus pay zone, because we do not know which particular pay zone is actually producing the majority of crude oil, whereas the rest of say 9 pay zones only contribute less than 10% of the oil.

We know we will need at least 4-drums of **GreenZyme®** here even for one target pay zone, we then pick a number, say 8-drums total for all 10 pay zones, and using say 2% **GreenZyme®** dilution strength for injection, followed by a much larger quantity of produced water, all inject through the casing-side of the well.

Even though we do not know exactly how much quantity of **GreenZyme®** goes to which individual pay zone, but we do know the total quantity of **GreenZyme®** and produced water we have injected; this is all right here, because from our past experience, we had seen the end-result of total oil increase is usually good, and the success rate is high, although a lot of guessing is used here.

Q22: What about horizontal oil wells and offshore oil wells?

A22: Same logic as question 20 above can be used here, pick a number greater than 4-drums and less than 12-drums **GreenZyme®**, depending on total daily fluid production. We can also expect good results. See table on **Q20** above.

Q23: What is the effective-radius do you use in GreenZyme® injection?

A23: All chemical and polymer injection into oil well usually need to calculate an effective radius-of-injection, which is usually only a small number.

Why? It is because all these chemicals and polymers diminish themselves when they enter into the pay zone, and then instantly react chemically with the crude oil and the formation-sands. In other words, they are not catalyst; their life-cycle is quick and short.

A successful oil well under chemical injection lasts only a few short months, and the total quantity of oil increase is quite small when compare with **GreenZyme®**.

However, the term effective-radius-of-injection for **GreenZyme®** is not quite appropriate to be used here, the reason being **GreenZyme®** is a biological catalyst; it does not react chemically with the crude oil and formation-sands.

The life-cycle for **GreenZyme®** is long lasting, in terms of many months and years in the formation, always working by diffusional forces inside the formation for months and years, until **GreenZyme®** is losing eventually in quantity slowly by flushing out with produced-water in the daily oil production.

The net increase in crude oil production by **GreenZyme®** in the treated oil well is usually huge when compare with those using chemicals and polymers injection.

Q24: What is the desirable shut-in time (i.e. capping time) required after finishing injecting GreenZyme® in my oil well?

A24: After injecting **GreenZyme®** into an oil well, the recommended shut-in time is as follow:

Shut-in Time (Days)	Oil well conditions
3 days	Oil density < 0.85; Porosity > 20%; Pour point temperature = OK.
4 days	Oil density < 0.90; Porosity > 20%; Pour point temperature = OK.
5 days	Oil density < 0.95; Porosity > 20%; Pour point temperature = OK.

6 days	Oil density < 1.00; Porosity > 20%; Pour point temperature = OK.
7 days	Oil density >1.00; Porosity > 20%; Pour point temperature = OK.
4 days	Oil density < 0.85; Porosity < 20%; Pour point temperature = OK.
5 days	Oil density < 0.90; Porosity < 20%; Pour point temperature = OK.
6 days	Oil density < 0.95; Porosity < 20%; Pour point temperature = OK.
7 days	Oil density < 1.00; Porosity < 20%; Pour point temperature = OK.
8 days	Oil density >1.00; Porosity < 20%; Pour point temperature = OK.
9 days	Every condition is BAD!

Q25: What can we observe during the usually five to ten hours of time when injecting GreenZyme® into my typical SFOW oil well, i.e. sufficient formation-pressure oil well?

A25: You can learn a lot about the underground formation by observing the pressure gauge readings alone during the **GreenZyme®** injection stage.

When an oil well shows a rapid decrease in oil production, one of the typical conditions is formation-blockage, i.e. positive skins formed under the sand-bearing formation.

These positive skins would hinder both crude oil and saline water flow, sometimes so severe that the tubing side fluid supply was reduced to practically “zero” at the pump. This required the oil well to be shut down.

During the **GreenZyme®** injection operation, the first diluted **GreenZyme®** when injected was shown to be under vacuum, the pressure gauge showed a negative reading.

A short while later, the pressure gauge then rose to zero PSI, (i.e. pound per square pressure) and then rose to the small positive side when **GreenZyme®** actually began entering the formation.

When half-way through the injection operation, very often we saw a “sudden surge” in pressure reading, say to 2000 PSI for a few minutes, and then followed by a “sudden drop” of pressure to say, 1200 PSI. This was an indication that a few near-bore head blockages had been broken down and cleared by **GreenZyme®**, a very good sign.

Sometimes we might observe more than one or two of these pressure-surge and pressure-drop phenomenon, a very good sign again.

Sometimes the pressure even rose to quite a scary pressure ranges, say from 3,500 PSI for five minutes, and then drop back to 1,800 PSI for twenty minutes. This again showed positive-skins bursting at locations further away from the bore-head of the oil well, again a very good sign.

Finally after all the **GreenZyme®** injection operation was finished, the pressure gauge might stay at a lower range, say only 1,100 PSI, this was the time for shut-in.

Q26: How do we determine if GreenZyme® injection process in my oil well was successful or not after resuming steady state fluid production?

Q26: After shut-in time, the first sign indicating that the Apollo **GreenZyme®** injection process was successful is a huge rise in static liquid level (SLL). The new SLL is very often and common to be six hundred meters higher than the pre-Apollo **GreenZyme®** injection reading, depending on the size and depth of the oil well.

Comment: a huge increase in the static liquid level (SLL) after Apollo **GreenZyme®** injection is a positive indicator that our process was successful.

Q27: What about water-cut after GreenZyme® injection?

A27: Water-cut reduction after **GreenZyme®** injection is not the deciding factor to judge the success or failure, only a raise in the new SLL is the positive factor judging for success.

A month or two after **GreenZyme®** injection, the majority of oil wells do show a slight reduction in the water-cut.

However many other wells show relatively stable water-cut percentages, but higher daily total fluid production. One thing in common is: all successful **GreenZyme®** treated oil wells do show a much higher SLL and total fluid production.

Q28: Can I keep my old production pumping rate after Apollo GreenZyme® injection?

A28: Absolutely no, in order to enjoy the oil production increases, you must increase the pumping rate after Apollo **GreenZyme®** injection.

With a new and raised SLL after Apollo **GreenZyme®** injection, a large quantity of “freed oil” near the vicinity of the perforation area is waiting to be pumped out immediately.

If you keep your old pumping rate as before, this large quantity of “freed oil” will be accumulated and aged near the vicinity of the perforation area, this “freed oil” then slowly begins to form positive skins, i.e. high pressure barrier zones, blocking fluid flow patterns and creating rapid reduction in total daily fluid production.

This is quite harmful to your oil well.

Q29: What happens after shut-in time is over and we begin to resume normal oil well production?

A29: After the capping time is over, normal oil well production can be resumed.

As soon as the renew production begins, the first sign is a new very high static liquid level (i.e. SLL) inside the tubing. This new and higher SLL is a solid proof that the **GreenZyme®** injection process was successful.

You should use this new SLL as a production guideline to increase your oil production rate; you can do this as follow:

- a) From the pump jack, raise the number of stokes-per-minute to a higher level. If the new SLL still keep on rising, you should raise the stokes-per-minute to an even higher level, until the new SLL maintains a steady and stable level. This will be the new daily fluid production rate of this oil well.
- b) Increase the length of the pump jack cylinder while maintain the same number of strokes-per-minute, to maintain a steady and stable new SLL.
- c) Or do both steps a) and b) above.
- d) If you use a submission pump, please increase the RPM of the pump rate.

At the beginning, total fluid production can show huge increases, with high water content coming out first for a few days or weeks, then gradually the oil-water ratio changes everyday towards more oil than water.

After a few weeks, this oil-water ratio becomes steady, with very little variations for the next few months. Total fluid production maintains at a steady and high production rate, depending on each individual oil well, this rate usually lasts anywhere from 12 to 18 months or more, before showing gradual slow decline later.

The total extra oil production using **GreenZyme®** injection can be a handsomely profitable and rewarding during this oil production time. This oil production enhancement is almost impossible to be achieved by using any other known EOR methods and processes.

Q30: How high a water-cut in percentage can I use GreenZyme®?

A30: We prefer **GreenZyme®** to be used on less than 80% water-cut.

However our authorized agent had been using **GreenZyme®** in water-cut as high as 90% with success. This is a straightly a cost-and-profit business decision. Normally we prefer water-cut level less than 75% for most **GreenZyme®** applications.

If your water-cut level is higher than 90+%, you may inject water-blocking chemicals first into your oil well, let the water-cut drops to below 75% level, then use **GreenZyme®** injection for E-EOR.

Q31: What will happen to my oil-water ratio (OWR) after shut-in time is over and I am resuming normal crude oil production?

A31: Immediately after resuming normal crude oil production, the following things may happen:

- a) A significant increase in the static liquid level (**SLL**) inside the tubing.
- b) A significant increase in total fluid release from the formation, in which the oil well operator needs to adjust by increasing the pumping rate base on the new higher static liquid level (**SLL**) available.
- c) A significant amount of water will come out first, depending on the total initial **GreenZyme®** injected.

The first few days or weeks can be mainly water. The oil-water ratio (**OWR**) will then begin to drop towards more oil than water after the initial periods of a few days or weeks, and finally become stabilized at a fairly stable **OWR**, which is similar to pre-**GreenZyme®** treatment level.

Very often the application of **GreenZyme®** process will reduce the water content slightly in the normal crude oil production, but the water-cut reduction is not a deciding factor to judge whether our **GreenZyme®** process was a success or not.

Q32: Can I re-inject GreenZyme® into my oil well after a successful previous treatment?

A32: Yes, you can reinject **GreenZyme®** into the same well after previous success job; there is no limitation on how many times you can use **GreenZyme®** in your oil well.

Q33: Is oil well spacing important in my GreenZyme® injection process?

A33: Yes, oil well spacing is important; we like each **GreenZyme®** treated oil well to have covered at least 40-acres of space (i.e. sand formation spacing) by itself if possible, the greater the spacing, the better, before meeting the next neighboring oil well of the same depth and at same formation.

Comment: if you have two oil wells very close to each other, and both oil wells are drilled into the same formation depth, you can use the **GreenZyme®** injection process for both wells at the same time.

Please be noted that, if you have decided not to treat the two adjacent oil wells at the same time, then by using **GreenZyme®** injection process on only one oil well, and if the neighboring non-treated oil well is only 100 yards away, then **GreenZyme®** will affect oil production of both wells with enhancement, but the total net oil increase is smaller than if you have treated both two oil wells together at the same timing.

Q34: If I have two oil wells with very similar conditions, say the first oil well is currently producing 2 barrels of oil per day (i.e. 2 BOPD); the second well is 50 BOPD. Which well should I try the GreenZyme® application first?

A34: Definitely you should try the second oil well first, i.e. the one currently producing 50 BOPD. Why? This is a simple economical decision, the reasons are as follow:

Since all conditions (e.g. geological formation etc) are similar between these two oil wells, then we are required to use the same quantity of **GreenZyme®** for each of these two wells.

Assume the **GreenZyme®** application is successful for both of these two oil wells, and each oil well recorded a five-fold increase in crude oil production for the next 12 months. Then simple mathematics will give you the following results:

Total net increase in oil production for **First Well** = $(5 \times 2 - 2) \times 365$ barrels
 = 2,920 barrels (minimum)

Total net increase in oil production for **Second Well** = $(5 \times 50 - 50) \times 365$ barrels
 = 73,000 barrels (minimum)

Note: the **Second Well** can bring a much higher return in profit to the oil well owner than the **First Well** using the same quantity of **GreenZyme®**.

Conclusion:

- a) Apollo **GreenZyme®** can bring significant profit return to the oil well owner. **GreenZyme®** is not a last resort for saving dying oil wells, although **GreenZyme®** may well be capable of doing so, but the profit in return can be compromised.
- b) The main function for **GreenZyme®** is to rapidly increase oil production and to bring maximum profits to the oil well owner.
- c) We try to discourage our customers to use **Greenzyme®** in any oil well producing less than 10 BOPD.

Q35: If my oil well has been treated previously by other enhanced-oil-recovery (i.e. EOR) methods, can my oil well still be good for the enzyme-based biological method utilizing Apollo GreenZyme® injection?

A35: Yes absolutely, your oil well can still be good for the Apollo **GreenZyme®** process. We have numerous successful **GreenZyme®** treated oil wells that had been previously treated with acid jobs, hot oil jobs, living microbes-injection jobs, chemical polymer jobs, steam-injection jobs, as well as fracturing jobs.

Q36: My oil wells are under steam-injection and huff-and-puff production cycles right now, can Apollo GreenZyme® injection process offer any help?

A36: Yes, Apollo **GreenZyme®** injection process can work very well and synergistically with your steam-injection process.

Some oil wells with heavy oil due to temperature, wax and other geological problems can only be effective using steam-injection cyclic process.

However if you use Apollo **GreenZyme®** injection first before your routine steam-injection in your oil well, the total crude oil recovery can be significantly higher in quantity per cycle than the one by steam-injection alone.

Q37: My oil well had been fractured before, can I use GreenZyme® injection also?

A37: Yes, see the same logic here as in question 36 above.

Q38: Can I use GreenZyme® on my gas well?

A38: **GreenZyme®** cannot work on 100% gas well; **GreenZyme®** works only on oil producing well.

For mixed well, i.e. a well is producing both crude oil and natural gas, economics will determine whether this well is a good candidate for **GreenZyme®** or not.

If your well is producing 60% equivalent gas and 40% equivalent crude oil, then **GreenZyme®** can be used in this well to affect the 40% oil-equivalent-portion only, i.e. crude oil production can be increased by **GreenZyme®**, but not much for the natural gas.

Q39: I have water-conning problem on my oil well, with 90+% water-cut and still gradually increasing daily. Should I use GreenZyme® in this well?

A39: You should solve the water-cut problem first before using **GreenZyme®**. For instance, you can use water-blocking chemicals to reduce the water-cut to below 75% first, and then use **GreenZyme®** injection for this oil well.

Q40: I have sand-control problems in my oil well, should I use GreenZyme®?

A40: You should solve the sand leaking problems first before using **GreenZyme®**. For instance, you can use sand-control chemicals and sand-control screens to solve the problems first, and then use **GreenZyme®** injection in this well.

Q41: How long can GreenZyme® be stored and use effectively?

A41: **GreenZyme®** is most effective if used within 3 years of manufacturing.

We recommend **GreenZyme®** be stored indoor from temperatures between 35 to 110 degrees F.

Under prolonged storage, the top of the **GreenZyme®** plastic drum may show slight bloated shape, this is absolutely normal for **GreenZyme®** under storage, because a small quantity of carbon dioxide (i.e. non-toxic due to small amount only) has been built-up under pressure inside the plastic drum. You may easily release this pressure built-up inside the plastic drum, from time to time, by opening one of the tight top caps and then immediately re-closes the top cap tightly.

Q42: Is there a method to evaluate GreenZyme® for quality control purpose?

A42: Unlike chemical products, there is no easy direct analysis method for a biological product like **GreenZyme®**.

For example: there is no chemical analysis method to measure the quality of a chicken egg inside or outside. Although you can look at the outside shell-size and color of this egg, but you still do not know the inside is good or bad.

You just have to “trust” the chicken farmer that all of his chickens were fed with “good-feed”, and all of his chickens were healthy before-and-after laying the eggs. These are the chicken eggs you buy from the food market every day.

Similarly this logic is also true when we produce **GreenZyme®**.

From batch to batch, we do have to follow straight procedures to safe guard our products to be good each and every time. We do not have any problems in quality control for **GreenZyme®**.

There is a quick and indirect method to check whether **GreenZyme®** is still in good working condition or not is to do a simple shaker-test. How?

First, place some oily-sludge sample in a glass bottle or a beaker, add 3 times its own volume of water, and shake the sample vigorously for one minute.

You will see no oil or very little oil has been released on top of the water-layer.

Now add a few drops of **GreenZyme®** to the same sample, shake it vigorously again for one minute of time. This time you will see a lot of oil had been released; this indicates that the **GreenZyme®** sample you have in hand is still in good working condition.

Q43: I had left a drum of GreenZyme® outdoor below freezing, what should I do?

A43: Your **GreenZyme®** is still good, just bring the drum indoor for slow de-freezing, the content inside the drum is still 100% useable.

Q44: What is the best way to start using Apollo GreenZyme® in my oil wells?

A44: The best way is to trust nobody but practice and gain experience by you.

Just pick a trial of say 3 oil wells, and then start injecting **Apollo GreenZyme®** to gain first experience.

See how the 3 oil wells perform and the net gain of crude oil over time. Judge only by the end results to evaluate the ability of **GreenZyme®** in EOR projects.

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