

**August 5, 2001**

**Analysis Report of Crude Oil Recovery Enhancement Using  
Apollo Greenzyme®**

**Dongxin Technical Institute,  
Third Gathering Station., Oil well Yung-8-52  
Shengli Oilfield, China**

(Production data and results updated to November 15, 2001)

## Effectiveness and application analysis using Apollo Greenzyme®

Apollo Separation Technologies Inc developed Apollo Greenzyme®, a new type of highly effective biological oil well unclogging agent.

In recent years, several foreign oil companies have tried to use this type of bio-enzyme to increase crude oil production, but in our nation, to use this new type of bio-enzyme to enhance oil production is still a blank page.

With introduction from Haichenxi Environment Protection & Technology Development Company of Beijing, together we worked with the technical personnel from Apollo Separation Technologies Inc in the month of July, we started our first unclogging oil well test work in Dongxin 3<sup>rd</sup> oil-gathering station, we have achieved outstanding end results.

According to introduction, Apollo Greenzyme® is a protein based non-living biological agent. It has a higher hydrocarbon oil-releasing capability from any solid surfaces. According to these particular characteristics, we chose Yung-8-52 oil well, and applied Apollo Greenzyme® to test its effectiveness.

Early stage results immediately after application of Apollo Greenzyme® showed: total daily fluid output : 17.7 m<sup>3</sup>, daily oil output : 16.9 m<sup>3</sup>, water content : 6%, dynamic fluid level : 412 m, the effect of Apollo Greenzyme® to unclog this oil well was very obvious. This speaks for itself that Greenzyme® has excellent effect to unclog heavy crude oil well for production enhancement.

1) **Well history**

On January 12 through 20, 2001, well was gravel-packed for sand control. Pumped 4t BHS sand-control chemical, 20 square thin-film expanding chemical 30 m<sup>3</sup> to oil-sand layers, pumping pressure started from 18 Mpa and dropped to 12 Mpa.

Lowered D44 long cylindrical pump, pump depth was 1604 m, production pump stroke was 6 m \* 1.8 times. Total production lasted only 23 days, ending in insufficient fluid flow.

On March 8 through 14, 2001, pulled out the pump and screen, did pump inspection, pumped 40 m<sup>3</sup> BHS oil well unclogging chemicals; on April 12 through 17, 2001, did pump inspection and sand detection. Pumped in 30 m<sup>3</sup> of demulsifying chemicals.

Production went on for 55 days, on June 13, production was stopped due to insufficiency of total fluid flow.

- Total cumulative production was 403 tons of oil, 780 tons total fluid.

**Reservoir characterization:**

<b>Reservoir Name</b>	<b>Oil Interval</b>	<b>Perforation Interval</b>	<b>Perforation Thickness</b>
<b>Sha 2-74</b>	<b>1894 -1993</b>	<b>1894-1989</b>	<b>5.0 m</b>

<b>Permeability *10<sup>-3</sup> μm</b>	<b>Porosity %</b>	<b>Clay %</b>
<b>1028</b>	<b>29.7</b>	<b>3.7</b>

**Basic data for this oil well**

<b>Date First Production</b>	<b>PBTD</b>	<b>Cement Top</b>	<b>Casing Size</b>
<b>Jan 2001</b>	<b>2084.9 m</b>	<b>1180 m</b>	<b>139.7*7.72</b>

<b>Oil Interval Thickness</b>	<b>Perforation Gun Type</b>	<b>Asphaltene Content</b>	<b>Perforation Density</b>
<b>4.45 m</b>	<b>102</b>	<b>0.46%</b>	<b>20 holes/m</b>

<b>Oil Viscosity</b>	<b>Oil Density</b>	<b>Wax Content</b>
<b>11281 mPa.s</b>	<b>0.9539</b>	<b>39.85%</b>

2) Well production history before applying Apollo Greenzyme®

Table 1

<b>Date</b>	<b>Pump Type</b>	<b>Daily Total Fluid t/d</b>	<b>Daily Oil Production t/d</b>	<b>Water Content %</b>	<b>Dynamic Fluid Level m</b>	<b>Remark</b>
<b>Feb 3</b>	<b>D44*6*1.8</b>	<b>12.6</b>	<b>6.3</b>	<b>50</b>	<b>1288.5</b>	
<b>Feb 7</b>	<b>D44*6*1.8</b>	<b>6.0</b>	<b>4.3</b>	<b>29.5</b>	<b>1204.6</b>	
<b>Feb 12</b>	<b>D44*6*1.8</b>	<b>5.7</b>	<b>4.0</b>	<b>29</b>		<b>Rod couldn't go down</b>
<b>Apr 24</b>	<b>D44*6*1.8</b>	<b>6.2</b>	<b>4.7</b>	<b>25</b>	<b>1577.1</b>	<b>Insufficient fluid flow</b>
<b>May 18</b>	<b>D44*6*1.8</b>	<b>9.3</b>	<b>5.8</b>	<b>38</b>	<b>1602</b>	<b>Insufficient fluid flow</b>
<b>Jun 6</b>	<b>D44*6*1.8</b>	<b>5.3</b>	<b>4.5</b>	<b>16.1</b>	<b>1560</b>	<b>Insufficient fluid flow</b>
<b>Jun 13</b>	<b>Insufficient fluid flow, stop production</b>				<b>June 18, static fluid level was 840 m</b>	

## Greenzyme<sup>®</sup> Application

### **Reasons why we had previously used unclogging chemicals in this well (before Apollo Greenzyme<sup>®</sup>)**

After applying gravel-pack for sand control on Yung-8-25 well, continuous oil production lasted for only 23 days, initial total daily fluid production reached a maximum of 17.6 m<sup>3</sup>/d, maximum daily oil production reached 8.0 ton/d, water content was 54.7% level. However production soon decreased rapidly, and this well was completely shut-off due to insufficient daily fluid flow.

We believed, the main reason this well could not perform normally was due to the high viscosity of the crude oil, this oil had low flow mobility, easily plugged up flow channels in the formation. In addition, this well also leaked out fine sands, mixing together with this crude oil, the mixtures adhered to both the perforation holes and the near vicinity of the formation.

Although initially, this well had experienced higher fluid production, as soon as both the perforation holes and vicinity were plugging-up, crude oil mobility resistance had also increased, causing insufficient fluid flow, which in turn significantly dropped the daily total fluid production.

To find a solution to this problem later on, although we applied viscosity-lowering chemicals to this well, we had not solved the fundamental problem here, which was caused by the mixing of this thick crude with sand and the plugging of the perforation holes in the formation. For this reason, this well had never performed under normal oil production.

Biological enzyme injection has one big characteristic and advantage in this application, it can liberate crude oil from the sand and without consuming itself in the process, thus lowering crude-oil mobility resistance, increasing the pay zone formation to supply more oil to increase total production.

6) Procedures for Greenzyme® applications

July 19, 2001

- Time : 10:50 AM** Fed 4 m<sup>3</sup> of diesel to well, no pump pressure needed, the formation sucked in the diesel under vacuum.
- Time: 10:55 AM** (10% strength Apollo Greenzyme®)  
Started pumping 8 m<sup>3</sup> into well, using a triplex feed-pump.  
Pumping pressure started to rise from 0 Mpa to 14 Mpa, then we shifted to a higher pump gear to raise the pressure from 16 Mpa to 17 Mpa.
- Time: 11:20 AM** Pressure indicator suddenly dropped to 10 Mpa, after a few minutes of time, pumping pressure restored back to 17 Mpa, and remained stable there.
- Time: 11:27 AM** Finished pumping all Apollo Greenzyme®, pressure indicator stayed steady at 16 Mpa.
- Time: 11:30 AM** Pumped another 6 m<sup>3</sup> of diesel, pressure remained stable at 16 Mpa.
- Time: 12:00 noon** All Apollo Greenzyme® injection work had been completed. Top of this well was capped for underground bio-reaction.

July 26, 2001

Lowered into well the production pump, the long cylindrical D44 pump, to 1,600 m depth, pump type D44\*6\*1.8, theoretical production capacity was 23.6 m<sup>3</sup> /d.

7) Well production treatment data after using Apollo **Greenzyme**<sup>®</sup>

**Table 2**

<b>Date</b>	<b>Pump Type</b>	<b>Daily Total Fluid, m<sup>3</sup></b>	<b>Daily Oil Production, m<sup>3</sup></b>	<b>Water Content, %</b>	<b>Dynamic Fluid Level, m</b>	<b>Remark</b>
<b>Jul 26</b>	<b>D44*6*1.8</b>	<b>14.6</b>	<b>0</b>	<b>100</b>	<b>665</b>	
<b>Jul 27</b>	<b>D44*6*1.8</b>	<b>6</b>	<b>3</b>	<b>50</b>		
<b>Jul 28</b>	<b>D44*6*2.2</b>	<b>8.4</b>	<b>6.7</b>	<b>10</b>	<b>412</b>	
<b>Jul 29</b>	<b>D44*6*2.2</b>	<b>14</b>	<b>12.6</b>	<b>10</b>		
<b>Jul 30</b>	<b>D44*6*2.2</b>	<b>17.7</b>	<b>16.6</b>	<b>6</b>		
<b>Jul 31</b>	<b>D44*6*2.2</b>	<b>19</b>	<b>16.86</b>	<b>6</b>	<b>716</b>	
<b>Aug 1</b>	<b>D44*6*2.2</b>	<b>19</b>	<b>16.86</b>	<b>6</b>	<b>716</b>	
<b>Aug 2</b>	<b>D44*6*2.2</b>	<b>20</b>	<b>18.8</b>	<b>6</b>	<b>718</b>	
<b>Aug 3</b>	<b>D44*6*2.2</b>	<b>22</b>	<b>20.68</b>	<b>6</b>	<b>716</b>	
<b>Aug 4</b>	<b>D44*6*2.2</b>	<b>23</b>	<b>21.62</b>	<b>6</b>	<b>716</b>	



Table 2 cont.

<b>Aug 5 th - Nov 15, 2001</b>					
<b>Pump Type</b>	<b>Daily Total Fluid, m<sup>3</sup></b>	<b>Daily Oil Production, m<sup>3</sup></b>	<b>Water Content, %</b>	<b>Dynamic Fluid Level, m</b>	<b>Remark</b>
<b>D44*6*2.2</b>	<b>Steady at about 25 m<sup>3</sup>/ day</b>	<b>Steady at about 23.5 m<sup>3</sup> / day</b>	<b>Steady at about 6% daily</b>	<b>Steady at about 716 m level</b>	<b>Running at steady state production</b>

8) **Performance comparison**

**Table 3**

Before and after application of Apollo Greenzyme®

<b>Total daily fluid production</b>	<b>Dynamic fluid level:</b>
<b>5.3 m<sup>3</sup> to 25 m<sup>3</sup></b>	<b>1560 m to 716 m</b>

<b>Total daily oil production</b>	<b>Changes in % water content from production</b>
<b>4.5 m<sup>3</sup>/d to 24 m<sup>3</sup>/d</b>	<b>16.1% to 6%</b>

**Note: Data from June 6 until well shut-off**

## Conclusion

- 1) After application of Apollo **Greenzyme**<sup>®</sup> to this well, we can see a significant increase in total daily fluid production. Previously we have to shut-off this well due to insufficient fluid flow before applying Apollo **Greenzyme**<sup>®</sup>.
  - Right now we have achieved a stable and steady fluid flow of over 23+ m<sup>3</sup> day, this is a significant increase in production, which indicates the highly effectiveness of using Apollo **Greenzyme**<sup>®</sup>.
- 2) Water content in crude oil was over 15% before application of Apollo **Greenzyme**<sup>®</sup>, however after application of Apollo **Greenzyme**<sup>®</sup>, current water content is a stable 6%, a significant drop.
- 3) The operating procedures using Apollo **Greenzyme**<sup>®</sup> to unclog oil well are quite simple; there is no environmental contamination problem

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Inc. of Houston, Texas USA