Dropping electrical bar perforation (DEBP) and safety auto-controlled system used in Oil-gas well

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Outline

1 Dropping electrical bar perforation (DEBP) technique
2 Safety auto-controlled technique
3 Experiments and tests
4 Comparison of detonating techniques
5 Conclusions
1 Dropping electrical bar perforation (DEBP) technique

DEBP is to drop the electrical bar to the target zone, which will fire the detonator to perforate.

- Electrical Bar

  Consists of firing head, power, energy releasing mechanism.

  Electrical bar for vertical well

  Used in vertical, deviated and diameter changing tube well

  Electrical bar for horizontal well

  Used in horizontal and highly deviated well
1. Dropping electrical bar perforation (DEBP) technique

- Electrical conductor connector

  Consists of stopping mechanism, contact, wire wheel and sink bar.

**FUNCTION:**

A. For TCP electrical connection for multiple stage perforation.

B. Signal indication between different stages.

C. Five zones could be done within 1000 m interval with single trip.
2 Safety auto-controlled technique

◆ According to principles of donating prevention, the keys of safety technique are safety precaution and safety protection.

◆ Items of safety precaution and safety protection:

① The most dangerous part: detonating mistakenly.
② The most dangerous period of time: the assembly and disassembly work
③ Detonator was the cause of explosion accident by mistake
④ The purpose of different kinds of detonators are to solve the safety problem with different approaches.
⑤ The causes of the detonator mistakenly blasting:

A. Internal aspect:
   Explosive is instable, so there are small probability self-explosive events.

B. External aspect:
   a. the environmental causes: static, RF power, and the interference of stray current.
   b. human errors: things falling into wellbore, improper operation, and accidently powering up the detonators.
2 Safety auto-controlled technique

◆ Safety precaution perforation technique

Purpose: reduce or avoid accidents

Approach: controlling and eliminating explosive factors

a. short circuit
b. open circuit
c. shielded

Pressure controlled switch  Short circuit mechanism  Timely delayed detonator

SL- detonator
2 Safety auto-controlled technique

◆ Safety protection perforation technique

Purpose: avoid gun firing mistakenly.

Approach: absorb explosive energy of detonating mistakenly.
adopt isolating devices.

Isolating device
3 Experiments and tests

3.1 Powering up mistakenly experiment

(Please watch the Flash shown in the Chinese PPT)

Experiment:

Artificially apply 220V to the safe detonating system

A-220V Power Source;  K-Switch;  2-SL-detonator;  3-Isolating device;  5-detonating tube;  6-detonating cord;  7-charge;  12-gun

Performance: SL detonator did not be fired after 2 min with ‘K’ on.
3 Experiments and tests

3.2 Detonator self-exploded test

(Please watch the Flash shown in the Chinese PPT)

Experiment: Change the structure of SL-detonator to power it up, and then fire the detonator artificially.

Performance: No energy transmitted to the booster and detonating cord, then the shaped charges in the gun string will be safe.

The safety protection device has been used nearly 100,000 times actual applications, and none of them failed.
3.3 Electric field radiation sensitivity experiment

- According to methods RS103 10 KHZ - 18 GHZ electric field radiation sensitivity, 200 v/M field strength value stipulated in military specifications GJB152A - 97 GJB152A - 97 military equipment and subsystem electromagnetic emission and sensitivity measurements, 8 detonators had been inspected. All of them passed the test.

- In the 3 cm and 10 cm pulse radar irradiation tests, detonators were respectively 4 m, 3 m, 2 m and 1 m away from. Radiation time was 1 minute. 8 detonators were safe.

- 2-32 MHZ extremely dangerous spectrum signal was fed directly into the detonator. Time was 1 minute. 4 detonators were safe.
4 Comparison of detonating techniques

Types of perforation detonator

- Traditional perforation approaches
  - TCP
  - WCP
    - Mechanical detonating
      - Tripped detonator
      - Pressure detonator
    - High resistance detonator
    - EFI detonator
    - Electromagnetic detonator
    - High current detonator
    - Countersunk head detonator
    - Raised head detonator

- Perforation approaches
  - TCP
  - WCP
    - DEBP
    - SL-detonator
4 Comparison of detonating techniques

4.1 DEBP for single stage

(Please watch the Flash shown in the Chinese PPT)
4 Comparison of detonating techniques

4.2 DEBP for multi-stage

(Please watch the Flash shown in the Chinese PPT)
4 Comparison of detonating techniques

4.3 DEBP for horizontal well

(Please watch the Flash shown in the Chinese PPT)
4 Comparison of detonating techniques

4.4 WCP

(Please watch the Flash shown in the Chinese PPT)
4 Comparison of detonating techniques

4.5 Field test

From March 10, 2012 to August 15, 2014, totally 240 Wells have been perforated with DEBP and SL-detonator in Shengli oilfield in China, 234 wells of which were successful.

<table>
<thead>
<tr>
<th>SL-detonator</th>
<th>Operation times</th>
<th>Operation Wells</th>
<th>Max thickness of interlayer (m)</th>
<th>Success rate(%)</th>
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<tr>
<td>WCP</td>
<td>90</td>
<td>90</td>
<td></td>
<td>100</td>
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<tr>
<td>DEBP for single stage</td>
<td>135</td>
<td>130</td>
<td></td>
<td>96.2</td>
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<td>DEBP for two-stage</td>
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<td>152.9/26.9</td>
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<td>DEBP for horizontal well</td>
<td>5</td>
<td>5</td>
<td></td>
<td>100</td>
</tr>
</tbody>
</table>
5 Conclusions

1. DEBP can be used in vertical Wells, highly deviated wells and horizontal wells, and has been used in more than 200 wells in Shengli oilfield.
2. Compared with traditional detonating technology used in TCP, type and quantity of related components can be largely reduced. Therefore DEBP is more reliable and safe.
3. By DEBP, procedure is simplified and cost is reduced.
4. Safety auto-controlled system
   ① Safety precaution mechanism: short circuit, open circuit and shielded.
   ② Isolating and detonating safety protection devices.
   ③ Immune to electric field radiation and stray electrical current.
   ④ Detonator explosion by itself can be isolated very well.
   ⑤ Applied in over 10,000 wells in Shengli Oil field for both WCP and TCP.
Any Questions?

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Thanks!