Intelligent Electronic Firing Heads
Deep Water Applications - SLAP-39

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Agenda

- Deep Water TCP Perforating Challenges
- TCP Firing Heads
- Case Histories
- Benefits
Deep Water TCP Perforating Challenges

- Reservoir
  - Long Intervals
  - Muti zones reservoirs
  - Exploration conditions (Need for Foramtion Tests)
  - Deep wells (>6000 mt)
  - Deep Water Depth
- Long running time (Subsea Wellheads)
- Complex Completions
  - Intelligent
  - Several Valves operated by pressure
Deep Water TCP Perforating Challenges

- Controled / Redundant firing systems to fire more than one interval at the same run
- Limited Pressures to activate firing heads
- Ensurance of firing guns independently in combined intervals production strings and / or in Shoot and Pull Operations
Intelligent Electronic Firing Heads

- Electronic Firing Head, utilizes the IRIS Technology;
- Safety Mechanism:
  - Activated only at 75% of expected wellbore static pressure;
  - Secondary Explosives;
- Precise Delay Time;
- No mechanical moving parts, immune to solids in the well
- Deviated wells with partial cushions;
- Work as memory gauge with high definition for pressure data triggered by gun firing
BHF – Activated by Drop Bar

Running-in-hole position

Impact of drop bar actuates firing sequence

Pressure in tubing fires perforating guns

Fill joint

Release sleeve

Shear ring

Firing pin

Detonator

Detonating cord

Drop bar

Telltale

Hydrostatic pressure

Sheared ring

Atmospheric pressure

No-go

a
Case History Well # A

- Well to be completed in separate formations
  - Formation X : Single interval of xx Mt
  - Formation Y : 2 Intervals combined of xxx Mt
  - Formation X & Y separated by 200 Mt
- Shoot & Pull Operations in Deep water well
- No Packer required
- Poor GR signal for correlation
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<th>Description</th>
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<th>Threads</th>
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- Scraper 10 3/4"
- Radio/Active mark
- Production Valve
- Redundant Firing Head IEF/HDF
- RDT Firing Head BHF/HDF
- Interval X Lower
HDF – Absolute Pressure

- Main Firing Head for both Intervals in X & Y
- Absolute Pressure Required to activate Firing Head
- Hydrostatic Pressure responsible of detonation
- 9942 psi
- 10142 psi
- 12000 psi
- 3000 psi / 2 min
- LSV
- HSV

Delay time form X = 15 min
Delay time form Y = 30 min

Formation X
- Pressure to Shear at Downhole (HSV + OverKill) = 9942 psi
- Pressure to Shear at Surface (HSV + OverKill) = 11489 psi

Formation Y
- Pressure to Shear at Downhole (HSV + OverKill) = 10142 psi
- Pressure to Shear at Surface (HSV + OverKill) = 11609 psi

- Lower Firing Head with 15 min delay
- Upper Firing Head with 30 min delay

SLAP-39
IEF – Pressure Pulses

- Secondary firing system for lower interval
  - Activated by low pressure pulses
  - Precise Delay time as programmed
  - Firing Head activated only at 75% of Hydrostatic pressure
  - Imuned to RF
  - No Mechanical parts
  - No primary explosives

![Diagram showing pressure pulses and time delays](image)

SLAP-39
Case History Well # B

- Well to be completed in one formation
- Downhole full test string run with the guns to evaluate the well
- Well had cementing issue in which cement squeeze job been performed
After setting the packer and circulate xxx bbls of diesel to obtain the required UB, the IRDV (multi function valve) been circulated to close the circulation valve and open the downhole shut in valve. At this moment observed well head pressure of 1700 psi indicating formation communication suspecting the squeezed interval.

- Several Attempts proved leak in the squeeze
- Can not hold pressure
Case History Well # B

Firing Sequence

Whp (psi)

2400.00

2060.00

1720.00

1380.00

1040.00

700.00

Csgp (psi)

2000.00

1600.00

1200.00

800.00

400.00

0.00

Real data from STAN

Time

02:30:00

02:40:00

02:50:00

03:00:00

02:56:09 - 785 psi

1800 psi

1700 psi
Benefits

✓ Guns in Multiple zones with long spacing can use redundant selective firing systems resulted in spacers cost reduction (~200 M)

✓ Improved operations reliability:
  ✓ Reduced spacers connections risk
  ✓ Redundant controlled Firing heads even with open perfs operations
  ✓ Reduced pressure pulses vs high pressure operations

✓ Impact on Efficiency $$$:
  ✓ Combine 2 runs into one run ~~~~ 72 hrs Rig time
  ✓ Reduce making up time for spacers utilizing tubing