Perforating for Heavy Oil Cold Production In North West Saskatchewan and North East Alberta, Canada

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The introduction of running a rare earth magnet below a perforation carrier has recently become a widely accepted practice in heavy oil perforation operations. Although perforating charge manufactures have paid a little more attention in regards to depositing debris in well bores from the use of large entry hole products there remains few low and even less no debris liners available. The "perf magnet' greatly reduces the deposition of perforation debris. Refer to figure 1 for an example of the amount of debris recovered by a perf magnet from just a four meter DP/XBH perforation operation.

Please refer to the previous article's conclusions:

1. Closely review all pertinent data, sources of information and considerations such as open hole logs, cores (of the well/s in question or cores from the area), area geology, area geophysics, economics, logistics and most importantly (if available) past production experience to ensure the development of a congruent exploitation, drilling, completion and production strategy.[14]
2. Large diameter, high density, closely phased perforations be utilized, shot under balanced and covering the entire zone to provide a geometrically thorough disturbed zone, minimize plugging, enhance initial sanding and sustain production.

Recent trends are tending to steer away from #2 suggestion of "Large diameter, high density, closely phased perforations be utilized, shot under balanced and covering the entire zone to provide a geometrically thorough disturbed zone " and are based on #1 "considerations such as open hole logs, cores (of the well/s in question or cores from the area), area geology, area geophysics" in regards to over burden shale spalling, over burden shale collapse, casing damage, casing compression (from over burden subsidence), laminate pay exploitation, difficult sand production, and over bottom water production environments. The suggested perforating, completion, workover and production strategies trends for these situations are:

1. Over burden shale spalling[1]

   "Don't perforate right next to the shale" Strategy for reducing risk

   a. identify a buffer layer below shale to be not perforated
   b. thickness of buffer layer may depend on thickness of zone
   c. maintain a conservative draw down and avoid well bore trauma

   The buffer layer is expected to prevent shale spalling

2. Casing damage

   It is impossible to put holes in casing and not weaken it.

   When mining sand as done with current cold production practices and the over burden weight is transferred to the casing, no amount of reduction in the magnitude of perforating is going o prevent casing damage. Literally the weight

of the earth is being applied to the casing. The use of compressible casing, bare foot completions and various combinations of liners and drilling strategies are being experimented with. Various degrees of successes are being experienced. When lateral stresses are anticipated, as with overburden weight transfer, the use of phasing and shot patterns with charges aligned in one horizontal plain is strongly not recommended.

3. Casing compression (from over burden subsidence)[2]

   "Balanced, low angle, less aggressive perforating, slow initial PCP production"
   Strategy for reducing risk

   a. perforate balanced or slightly under balanced
   b. perforate less aggressively with no more than 120°,180° or 0° phasing
   c. slowly increase pressure draw down until production is initiated
   d. produce at a constant draw down until risk of destabilizing near well region becomes small

      (i.e. wormhole network is growing away from well)

   It is expected that stable sand pillars will form, supporting the over burden in the un-perforated region.

4. Laminate pay exploitation[3]

   "Balanced, low angle, less aggressive perforating, slow initial PCP production"

   Smaller entrance holes, less density/number and less radial density perforations – less break up of shale lamination*s.*

5. Difficult sand production environments[4]

   "Perforating While Foaming (PWF), Propellant Stimulation While Foaming (PSWF), propellant stimulation, surge CSE, reciprocating PCP with chemical"

   Enhancement of well bore trauma and large pressure perturbations is recommended.

6. Over bottom water production[5]

   A strategy for less aggressive perforating is suggested to prevent damage to any shale barriers or layers of poor vertical permeability that may be present between the oil and water. Large pressure perturbations are not recommended.

In regards to point 3 and 4 - Stable pillars harder to establish and maintain in thicker zones and are easy to establish between laminations

Though recent trends suggest less aggressive strategies perforation plugging still plagues heavy oil cold production and caution should be taken when sacrificing flow area for reasons demonstrated in the previous article. The exercise of choosing the best perforation products and practice remains and exercise in making the best compromises. It is important to understand the nature of produced debris that causes blockage, to determine if it is going to re-occur, to determine how far from the well bore blockage may occur and what completion, workover and/or

production strategy will be effective. The following chart shows examples of the different types of debris:

Formation

- Pyrite
- Shale
- Coal
- Chert
- Asphaltenes
- Waxes
- Silts and clays

Will probably re-occur

Other

- Drilling mud
- Cement
- Perf debris

Possible to remedy with workover/s

The recent trends to less aggressive perforating also stems from the availability and advent of more tools to dislodge and prevent blockage mechanisms. A not a complete list of some of these tools is:

- Sand bailers and tubing bailers
- Flushes and superflushes
- Select perf washes and perf cleaning
- PC pumps and charge pumps
- Equipment upgrades
- Pump to surface
- Reperfs, reperfs and reperfs
- Chemical treatments
- Stable foam clean outs and stimulations
- Continuous Sand Extraction (CSE)
- Propellant stimulation
- Pressure pulsing
- Load with chemicals
- Flush with chemicals
- Perf/foam
- Foam/propellant
- Perf/propellant
- Propellant with chemicals
- Pulsed chemicals
- Pulsed CSE
- Abrasi jet/frac sand
- Abrasi jet/foam
- Foam acid frac

All of the above strategies have been brought forward recently. 3 as of this writing has not been tried. 4 has been done with alternate technologies from explosive perforating. PWF has been done numerous times and tracked and reported in a presentation by Ryan Rueve, Nexen Inc. at the Petroleum Society of CIM Lloydminster Heavy Oil Section 2003 symposium (refer to figures 2,3 and 4). 1 and 6 have been done but as of this writing, no tracking has been reported.

Foot Notes

[1, 2, 3 and 4] These concepts were brought forward in workshops conducted by Ron Sawatzky and Kirby Hayes entitled "***Extreme Completion, Workover and Production Techniques for Cold Heavy Oil Production"*** presented in 2003 and 2004.

[3 and 5] These concepts were brought forward by Cedic Gall in 2003 albeit utilizing Penetrator and Abrasi jet technology to further minimize casing, cement and formation trauma.