Stimulation of shallow gas wells

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Successfully completing shallow gas wells can be a challenge – especially in intervals that are near water. In many instances perforating alone will not provide sufficient inflow performance. Low reservoir pressure does not generally provide adequate differential pressure and inflow velocities to flush the near-wellbore region. Remedial efforts such as modest "skin fracs," for near-wellbore stimulation, run the risk of connecting to water.

The StimGun™ assembly has been demonstrated to provide sufficient stimulation energy to clean up the near-wellbore region while remaining in the zone. Shallow gas wells stimulated using this advanced perforating technique have performed to potential without the need for additional costly and sometimes unpredictable stimulations. When dealing with near-wellbore production restrictions, propellant stimulation devices can be an inexpensive and effective method of clearing the formation and perforations. The focused nature of the stimulation means that it can be used in applications where more aggressive stimulations may result in the increase of undesirable near-water production.

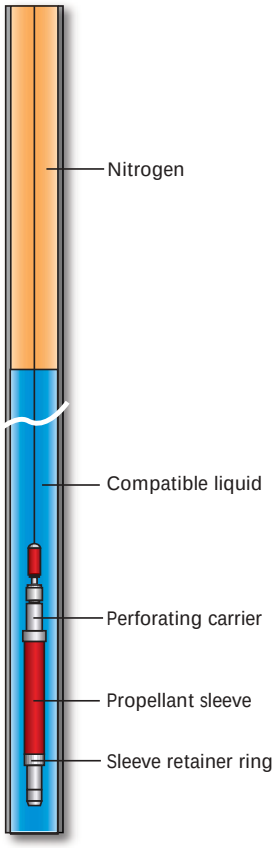

Figure 1 - *Wellbore schematic illustrating how nitrogen pressure has been utilized to increase propellant confining pressure.*

Mechanism

The stimulation mechanism for a StimGun treatment is identical to the stand-alone propellant tools with the unique difference that the propellant event takes place at the time of perforating. Once positioned on depth, detonating the shaped charge contained within the perforating carrier ignites the propellant sleeve. As the propellant burns, a surge of high-pressure gas is produced that enters the newly created perforation path, breaking through the damage around the perforation tunnel. For underbalanced stimulations, an increased back-flushing effect has been demonstrated to further enhance the stimulation.

Propellant devices require confining pressure in order to promote an efficient burn. Confining pressure is obtained by placing a fluid column of sufficient height over the propellant tool > 650 ft (>200 m) for the StimGun™ assembly. Twice the minimum amount is ideal. In shallow wells adequate fluid height sometimes cannot be obtained due to the depth of the well. In addition, placing excessive fluid over the interval is undesirable due to the low reservoir pressure and concern over fluid injection into the formation following perforation. An efficient propellant burn can be obtained by placing a minimal amount of a formation compatible fluid over the interval and applying adequate nitrogen pressure at the surface over that fluid column (see Figure 1). Effective confinement is obtained and the StimGun™ assembly can be ignited. After initiating the StimGun™ assembly, the nitrogen pressure is immediately released to minimize fluid injection and allow back-flushing of the formation.

Pressure data

When a high-speed pressure gauge is used, a graphical presentation of the stimulation event can be generated for analysis. The analysis can be used to determine the effect of the stimulation on the formation and to evaluate the burn of the propellant. The configuration and job execution for this application

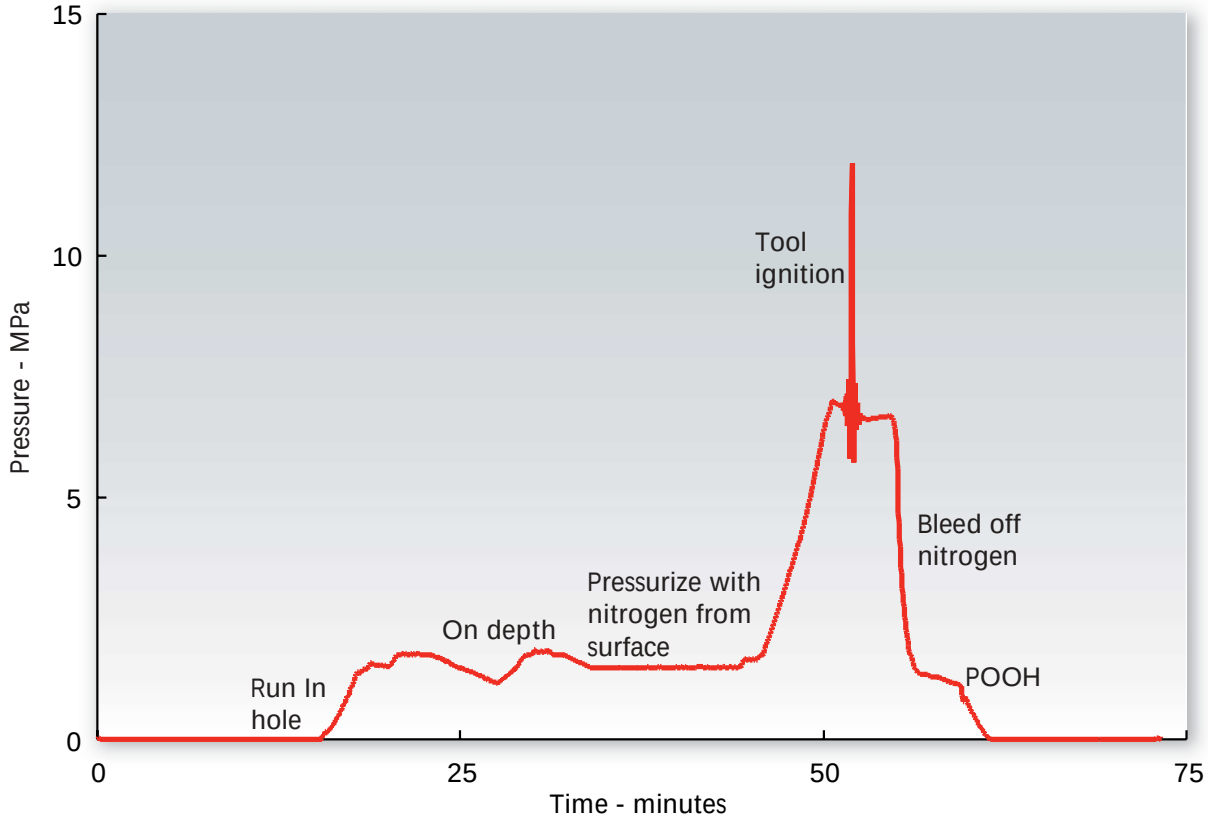

Figure 2 - *Example pressure plot illustrating well pressurization and post stimulation pressure bleed-off to minimize fluid injection.*

Case histories

Case 1

Objective: The interval has near water. Hydraulic fracturing brings in water production and standard perforating does not provide maximum expected inflow.

Solution: A StimGun™ assembly was run to initiate localized near-wellbore clean up.

Configuration:

- **Orientation:** Vertical
- **Formation:** Bluesky sandstone; 1132 ft (345 m)
- **Casing size:** 4½ in. (114.3 mm)
- **Tool:** 3.375 in. (85.7 mm) StimGun™ assembly over 2.75 in. (70 mm) ERHSC loaded at 6 spf (20 spm) & 60° phasing conveyed on wireline
- **Tamp:** KCl with 1000 psi (6.9 MPa) Nitrogen over pressure

Results: After completion with StimGun™ assembly, the well was producing at an acceptable rate of 225 mcf/d (6.4 E3m³/d), gas, with no observed water production. Hydraulic fracturing was avoided.

Case 2

Objective: The completion interval has near water. Previous fracing attempts in the field have brought in water production, and standard perforating does not provide maximum expected inflow.

Solution: A StimGun™ assembly was run to initiate localized near-wellbore clean up.

Configuration:

Orientation: Vertical

Formation: Bluesky sandstone; 1181 ft (360 m)

Casing size: 4½ in. (114.3 mm)

Tool: 3.375 in. (85.7 mm) StimGun™ assembly over 2.75 in. (70 mm) ERHSC loaded at 6 spf (20 spm) & 60° phasing conveyed on wireline

Tamp: Water/methanol with 1000 psi (6.9 MPa) Nitrogen over pressure

Results: After completion with StimGun™ assembly, the well was producing at 300 mcf/d (8.5 E3m³/d), gas, with a WGR of 8.4 bbl/mmcf (3.8 m³/100 E3m³). Hydraulic fracturing was avoided – production at acceptable rate.

Case 3

Objective: The completion interval has near water. Previous fracing attempts in the field have brought in water production, and standard perforating does not provide maximum expected inflow.

Solution: A StimGun™ assembly was run to initiate localized near-wellbore clean up.

Configuration:

Orientation: Vertical

Formation: Bluesky sandstone; 1335 ft (407 m)

Casing size: 4½ in. (114.3 mm)

Tool: 3.375 in. (85.7 mm) StimGun™ assembly over 2.75 in. (70 mm) ERHSC loaded at 6 spf (20 spm) & 60° phasing conveyed on wireline

Tamp: Water/methanol with 1000 psi (6.9 MPa) Nitrogen over pressure

Results: After completion with StimGun™ assembly, the well was producing at 5.9 E3m³/d (210 mcf/d), gas, with a WGR of 24.9 bbl/mmcf (11.3 m³/100 E3m³). Hydraulic fracturing was avoided – production at acceptable rate.

Case 4

Objective: The completion interval has near water. Previous fracing attempts in the field have brought in water production, and standard perforating does not provide maximum expected inflow.

Solution: A StimGun™ assembly was run to initiate localized near-wellbore clean up.

Configuration:

Orientation: Vertical

Formation: Bluesky sandstone; 1335 ft (406 m)

Casing size: 4½ in. (114.3 mm)

Tool: 3.375 in. (85.7 mm) StimGun™ assembly over 2.75 in. (70 mm) ERHSC loaded at 6 spf (20 spm) & 60° phasing conveyed on wireline.

Tamp: Water/methanol with 1000 psi (6.9 MPa) nitrogen over pressure.

Results: After completion with StimGun™ assembly, the well was producing at 153 mcf/d (4.3 E3m³/d), gas, with a WGR of 6.7 bbl/mmcf (3.0 m³/100 E3m³). Hydraulic fracture was avoided – production at acceptable rate.

Case 5

Objective: The completion interval has near water. Previous fracing attempts in the field have brought in water production, and standard perforating does not provide maximum expected inflow.

Solution: A StimGun™ assembly was run to initiate localized near-wellbore clean up.

Configuration:

- **Orientation:** Vertical
- **Formation:** Bluesky sandstone; 1345 ft (410 m)
- **Casing size:** 4½ in. (114.3 mm)
- **Tool:** 3.375 in. (85.7 mm) StimGun™ assembly over 2.75 in. (70 mm) ERHSC loaded at 6 spf (20 spm) & 60° phasing conveyed on wireline
- **Tamp:** Water/Methanol with 1000 psi (6.9 MPa) Nitrogen over pressure

Results: After completion with StimGun™ assembly, the well was producing at 127 mcf/d (3.6 E3m³/d), gas, with no observable water production. Hydraulic fracturing was avoided – production at acceptable rate.

Case 6

Objective: The completion interval has near water. Previous fracing attempts in the field have brought in water production, and standard perforating does not provide maximum expected inflow.

Solution: A StimGun™ assembly was run to initiate localized near-wellbore clean up.

Configuration:

- **Orientation:** Vertical
- **Formation:** Bluesky sandstone; 1207 ft (368 m)
- **Casing size:** 4½ in. (114.3 mm)
- **Tool:** 3.375 in. (85.7 mm) StimGun™ assembly over 2.75 in. (70 mm) ERHSC loaded at 6 spf (20 spm) & 60° phasing conveyed on wireline
- **Tamp:** Water/Methanol with 1000 psi (6.9 MPa) Nitrogen over pressure

Results: After completion with StimGun™ assembly, the well was producing at 92 mcf/d (2.6 E3m³/d), gas, with no observable water production. Hydraulic fracturing was avoided – production at acceptable rate.

Case 7

Objective: The completion interval has near water. Previous fracing attempts in this field have brought in water production, and standard perforating does not provide maximum expected inflow.

Solution: A StimGun™ assembly was run to initiate localized near-wellbore clean up.

Configuration:

- **Orientation:** Vertical
- **Formation:** Bluesky sandstone; 1843 ft (257 m)
- **Casing size:** 4½ in. (114.3 mm)
- **Tool:** 3.375 in. (85.7 mm) StimGun™ assembly over 2.75 in. (70 mm) ERHSC loaded at 6 spf (20 spm) & 60° phasing conveyed on wireline
- **Tamp:** Water/Methanol with 1000 psi (6.9 MPa) Nitrogen over pressure

Results: After completion with StimGun™ assembly, the well was producing at 107 mcfd (3.0 E3m³/d), gas, with no observable water production. Hydraulic fracturing was avoided – production at acceptable rate.

Case 8

Objective: The completion interval has near water. Previous fracing attempts in this field have brought in water production, and standard perforating does not provide maximum expected inflow.

Solution: A StimGun™ assembly was run to initiate localized near-wellbore clean up.

Configuration:

- **Orientation:** Vertical
- **Formation:** Bluesky sandstone; 1119 ft (341 m)
- **Casing size:** 4½ in. (114.3 mm)
- **Tool:** 3.375 in. (85.7 mm) StimGun™ assembly over 2.75 in. (70 mm) ERHSC loaded at 6 spf (20 spm) & 60° phasing conveyed on wireline
- **Tamp:** Water/methanol with 1000 psi (6.9 MPa) nitrogen over pressure

Results: After completion with StimGun™ assembly, the well was producing at 236 mcf/d (6.7 E3m³/d), gas, with a WGR of 2.6 bbl/mmcf (1.2 m³/100 E3m³). Hydraulic fracturing was avoided – production at acceptable rate.

Case 9

Objective: The completion interval has near water. Previous fracing attempts in this field have brought in water production, and standard perforating does not provide maximum expected inflow.

Solution: A StimGun™ assembly was run to initiate localized near-wellbore clean up.

Configuration:

- **Orientation:** Vertical
- **Formation:** Bluesky sandstone; 1171 ft (357 m)
- **Casing size:** 4½ in. (114.3mm)
- **Tool:** 3.375 in. (85.7 mm) StimGun™ assembly over 2.75 in. (70 mm) ERHSC loaded at 6 spf (20 spm) & 60° phasing conveyed on wireline
- **Tamp:** Water/methanol with 1000 psi (6.9 MPa) nitrogen over pressure

Results: After completion with StimGun™ assembly, the well was producing at 206 mcf/d (5.8 E3m³/d), gas, with a WGR of 11.69 bbl/mmcf (5.3 m³/100 E3/m³). Hydraulic fracturing was avoided – production at acceptable rate.

makes the pressure recording an important tool to determine if the propellant burned correctly.

Conclusions

Applications have demonstrated that the StimGun™ assembly can be an effective method of stimulating shallow wells.

- In many instances perforating alone will not provide sufficient inflow performance because the low reservoir pressure does not clean up the near-wellbore region.
- Remedial efforts such as modest “skin fracs” run the risk of connecting to water.
- The StimGun™ assembly has been demonstrated to provide sufficient stimulation energy to clean up the near-wellbore region while remaining in zone.