2019 NAPS

NORTH AMERICA PERFORATING SYMPOSIUM

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Propellant-Assisted Technologies Successfully Deployed in Middle-East & South Asia to Enhance Productivity

BAKER HUGHES a GE company

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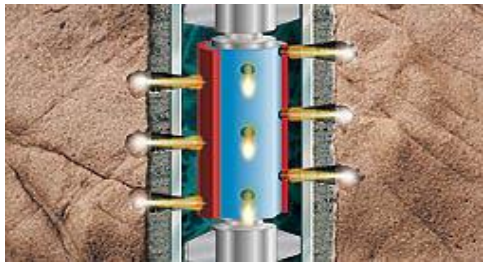
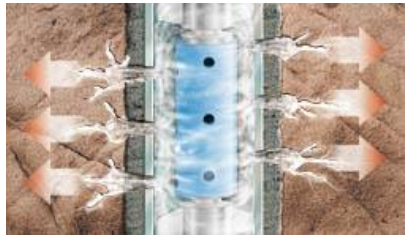
AGENDA

- INTRODUCTION
- SOFTWARE MODELING
- CASE HISTORIES
  - Propellants combined with Acid
  - Propellant around a perforating gun
  - Propellant inside a perforating gun
- CONCLUSIONS

Principle and Benefits of Propellants

Step 1: A sleeve of propellant is placed over the conventional perforating gun and positioned across the zone of interest.





Step 2: As the gun detonates it in turn ignites the propellant sleeve. The pressure generated is sufficient to fracture the formation near the wellbore and open up the perforations.

Step 3: The propellant sleeves generate as much as 25,000 psi at the perforations. This technique has been especially successful when used in underbalanced TCP completions.

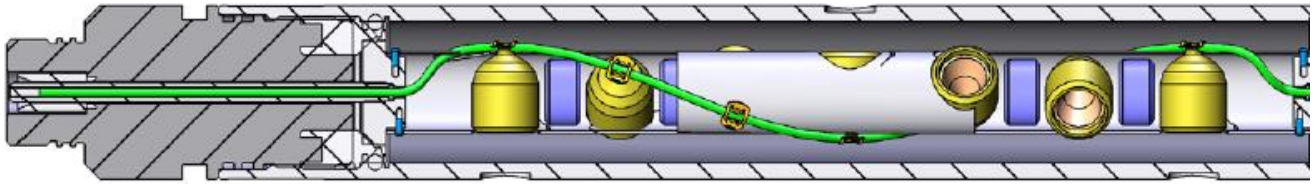
BENEFITS

- Enhance well productivity or injectivity
- Deliver perforation breakdown and cleanup
- Deliver near-wellbore stimulation
- Overcome formation damage created during the perforating event
- Reduce hydraulic fracture initiation pressures and improve proppant placement

INTRODUCTION

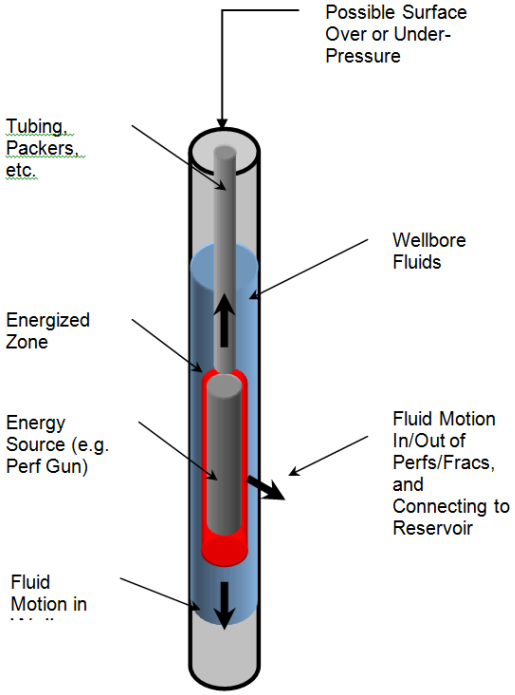
Types of Propellant Applications

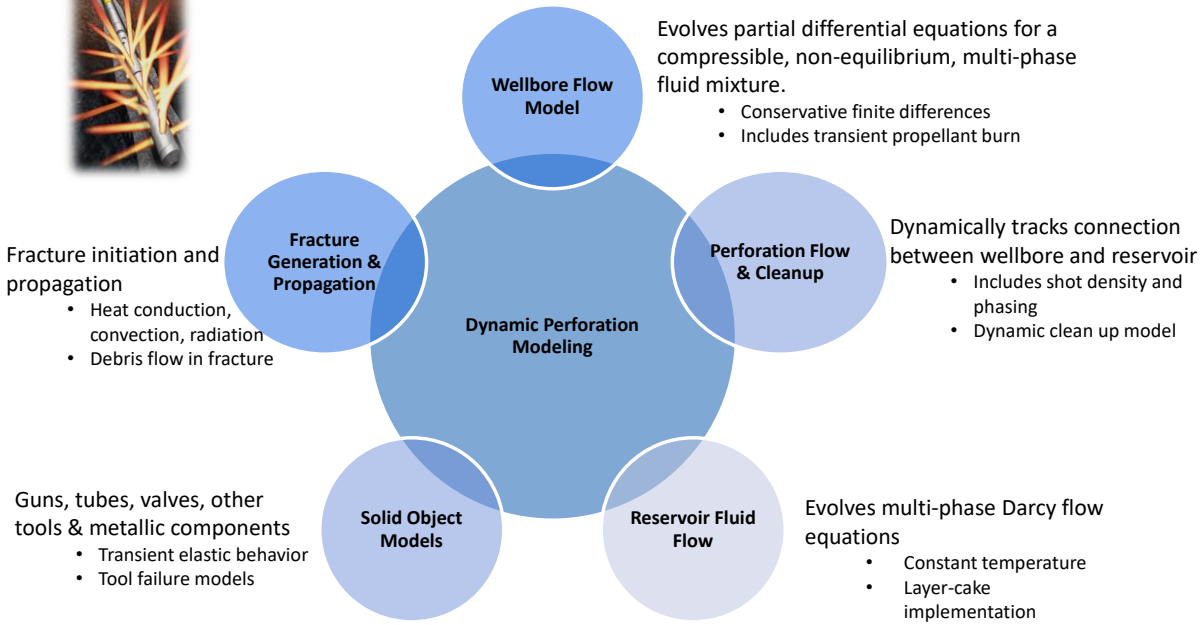
- Sleeve of propellant placed over a conventional perforating gun
- Molded cylinder with propellant like oxidizing material surrounding an internal steel support tube
- Internal propellants arranged within the perforating system



Modeling Software

Software platform for computational modeling of transient, downhole perforating events





CASE-HISTORY

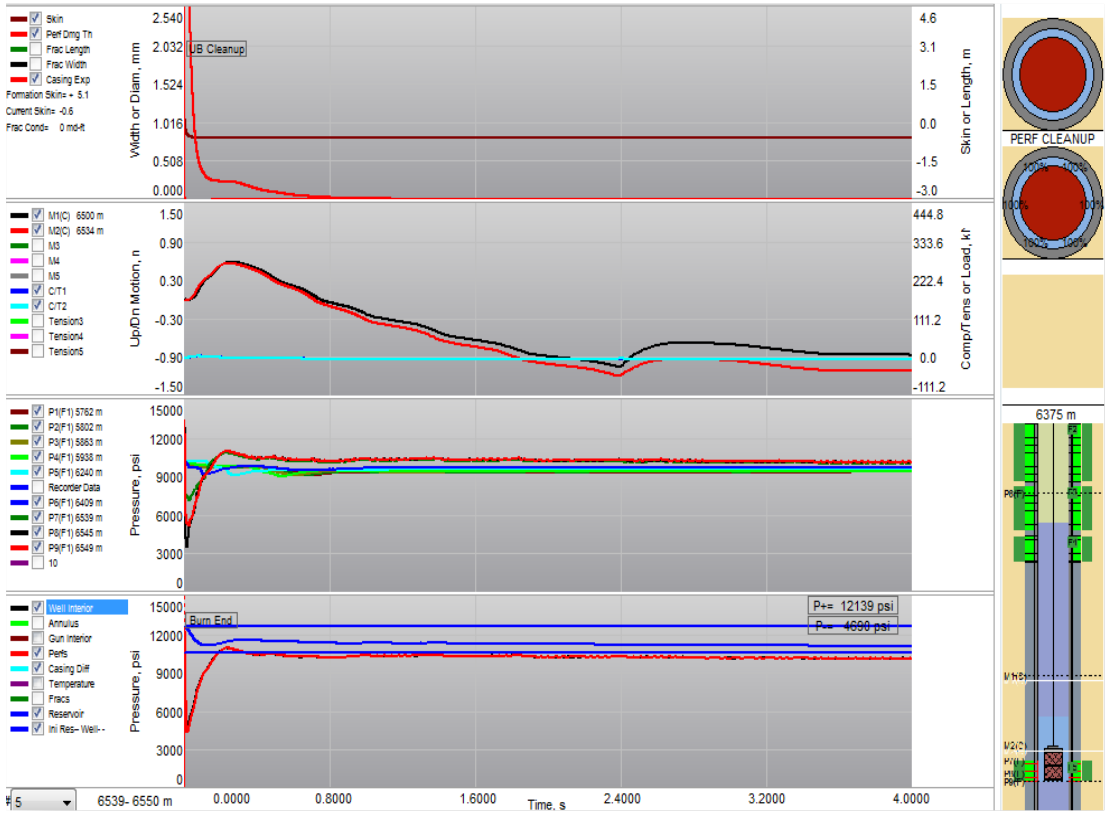
PROPELLANT COMBINED WITH ACID

- Well drilled and completed in 2016 with achieved productivity of both oil and gas as expected
- Overall productivity was reduced by > 50% over the first 12 months of production
- Customer seeking solution to restore productivity

CASE-HISTORY

PROPELLANT COMBINED WITH ACID

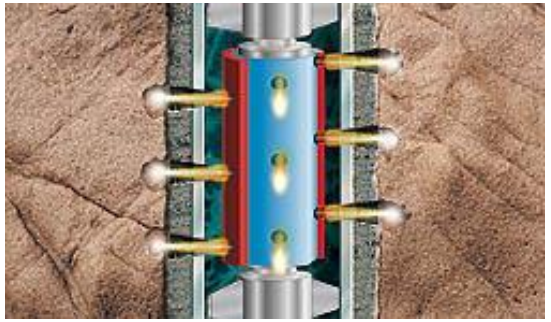
- Application of propellants (Stimtube) + acid treatment to rejuvenate productivity
- Spot acid against the perforated interval, and run 2” propellant tube inside the acid.
- Propellant as the driving force for acid, to induce fractures and most importantly, capitalize on the newly created fractures with the soaked acid.
- Dynamic event modeling used to design job, mitigate risk and estimate injection rates

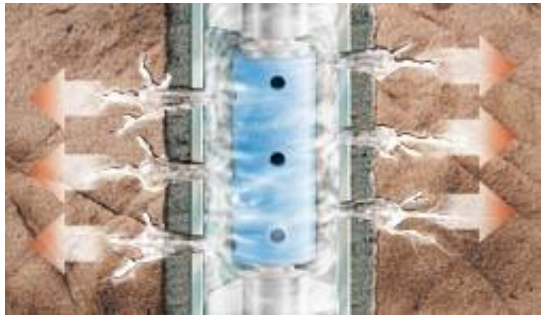


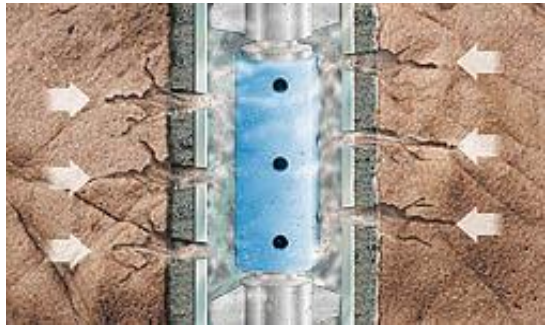
CASE-HISTORY

PROPELLANT COMBINED WITH ACID

- Multiple runs to spot acid using the propellants resulted in a successful operation
- Post-job analysis indicated that the overall flow rates and productivity exceeded expectations
- Flawless execution of this operation in treating formation damage and stimulating the well has prompted the operator to execute similar strategy for other wells in the future



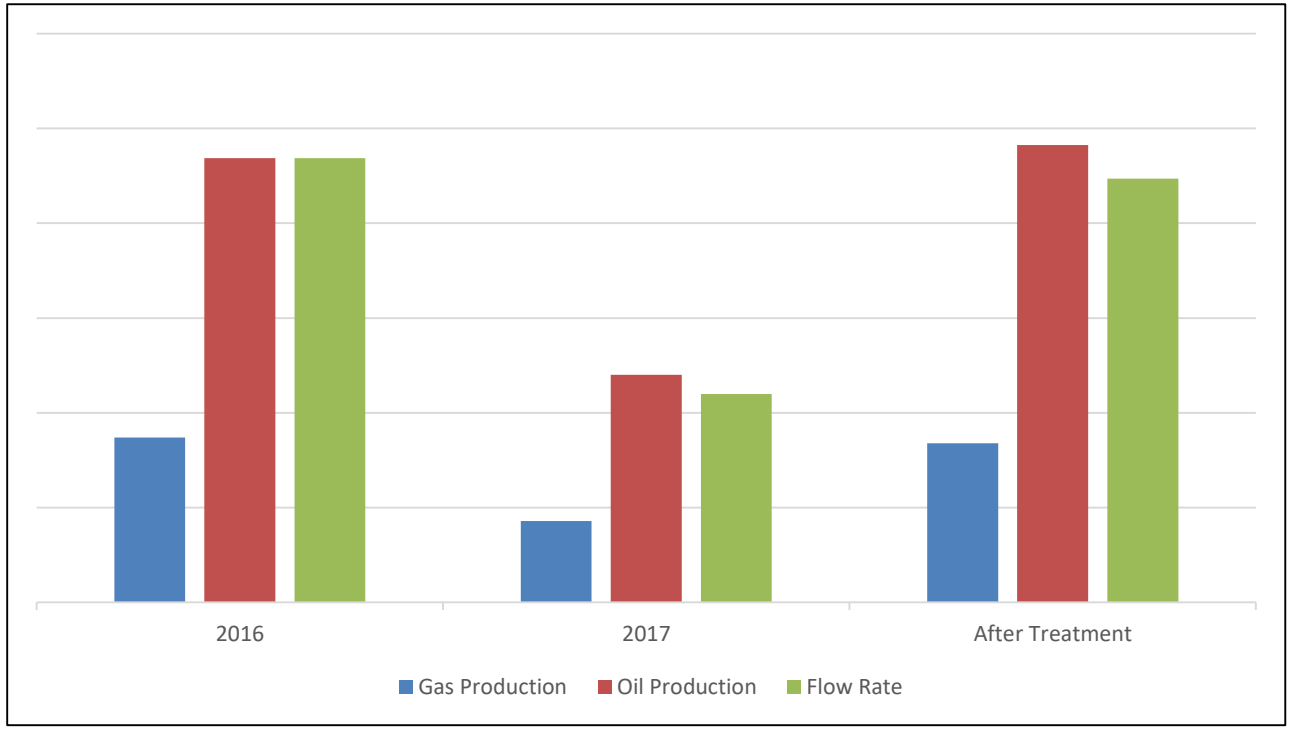




CASE-HISTORY

PROPELLANT COMBINED WITH ACID

- Combining Acid treatment and Propellant as a driver successfully restored production to original rates
- Pre-job modelling optimized operation design and ensured successful and safe deployment
- Multiple wells successfully stimulated till date with a plan to stimulate more wells in the future



CASE-HISTORY

PROPELLANT AROUND A PERFORATING GUN

- An Exploratory well in South Asia was drilled to explore the formation.
- Based on the integrated study of geological and geophysical data, four objects were approved for initial production testing.
- All objects were in the same formation.
- This sandstone formation has 12 % porosity, 60% water saturation and 1-5 mD permeability, with high stress magnitude (~0.75 psi/ft).
- The objective of the testing was to identify fluid type, flow rate and pressure data to build a rich reservoir model.

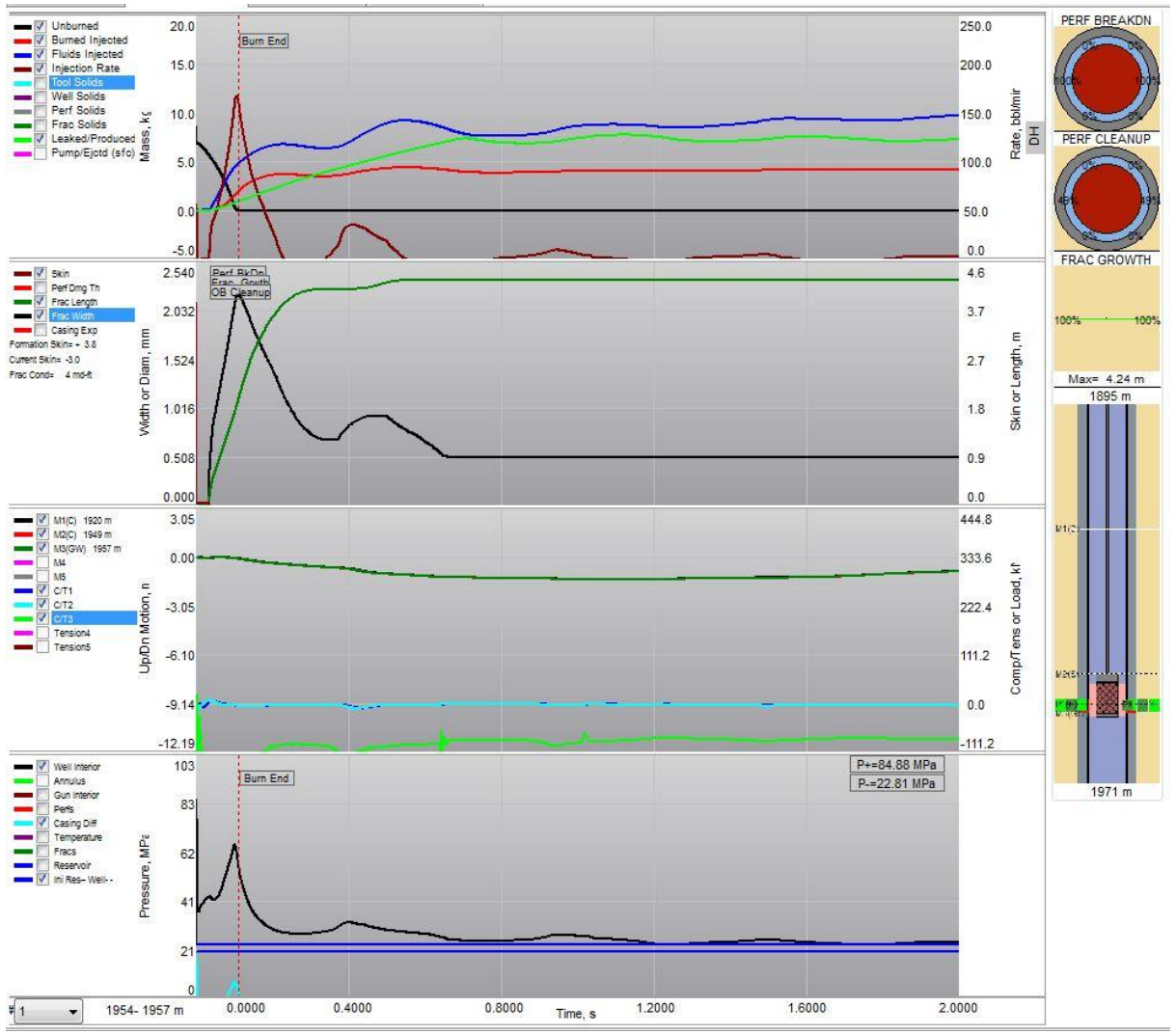
PROPELLANT AROUND A PERFORATING GUN

- Overbalanced perforations with wireline were required, so as to test many objects in the same well without lowering the completion string
- Low permeability did not provide good perforation clean-up.
- With conventional perforation, the expected flow could not be achieved due to the possible presence of skin factor.
- The challenge was to overcome the near wellbore damage in order to connect the wellbore with uninvaded formation.
- **Propellant-assisted technology** was recommended to penetrate near wellbore damage, reducing skin and mildly stimulating the well.

CASE-HISTORY

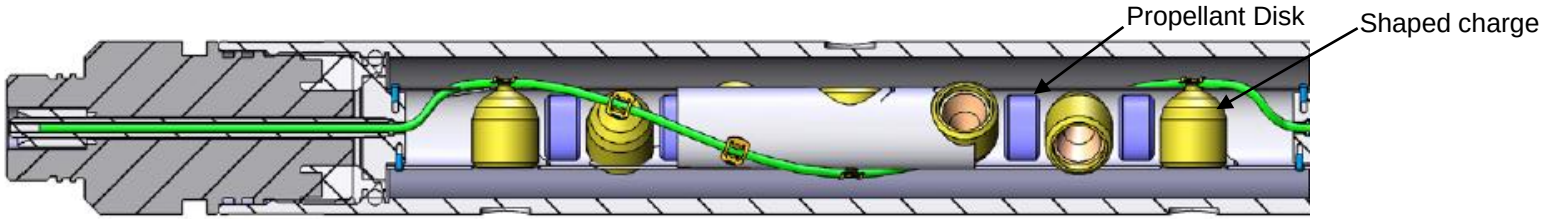
PROPELLANT AROUND A PERFORATING GUN

- The model assumed an initial positive skin of 3.8 and 5 mD permeability.
- Model results estimate
  post treatment skin of -3,
  100% perforation break down,
  bi-wing fractures ~4.24 m in length,
  fracture conductivity index of ~4mD/ft
- No warnings or flags were observed.
- Successful deployment of the propellant applications yielded positive results, PLT Results-
  3mm bean: 7146m3/day.
  4mm bean: 9536m3/day.
  5mm bean: 14093m3/day.



INTERNAL PROPELLANTS WITHIN THE PERF GUN

- Combines perforating and well stimulation in one operation.
- The system integrates perforating charges with a proprietary energetic material.
- The detonation of the perforating charges initiates a complex, sequentially burning reaction of the energetic material generating high pressure gas pulse.
- This pulse cleans the tunnel and initiates fractures into the surrounding reservoir improving production/injection performance.
- Successfully run in heavy oil SAGD (steam assisted gravity drainage) wells in Canada. Injection wells showed substantial increases in productivity.
- Tight unconventional reservoirs: West Texas field studies and Woodford shale studies have shown higher inflow performance and decrease in hydraulic fracturing breakdown pressures.



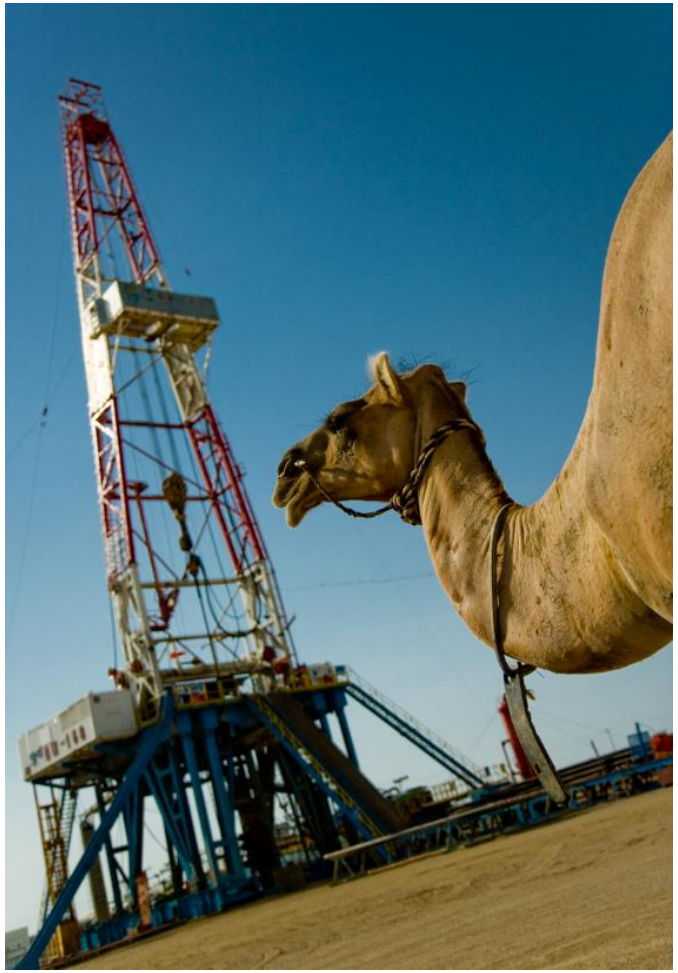
CASE-HISTORY

INTERNAL PROPELLANTS WITHIN THE PERF GUN

- An operator in the Middle East observed minimal fluid influx from the formation, which led to their ESP's heating up and eventually failing

- As a solution, it was decided to explore a propellant driven application to establish proper formation connectivity.

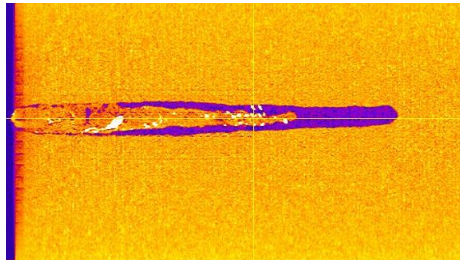
- Propellant application deployed on Multiple wells:
  - ✓ Wireline deployed
  - ✓ 3-1/8" perforating system (5 SPF, 60 deg phasing, 21 ft.) with internal propellants
  - ✓ Formation is a sandstone, with formation pressure ranging between 2000-4000psi



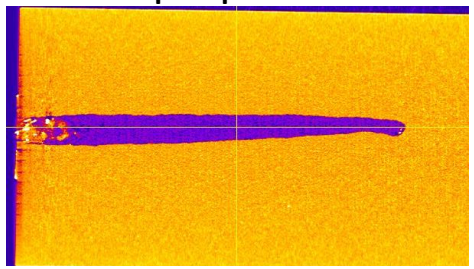
INTERNAL PROPELLANTS WITHIN THE PERF GUN

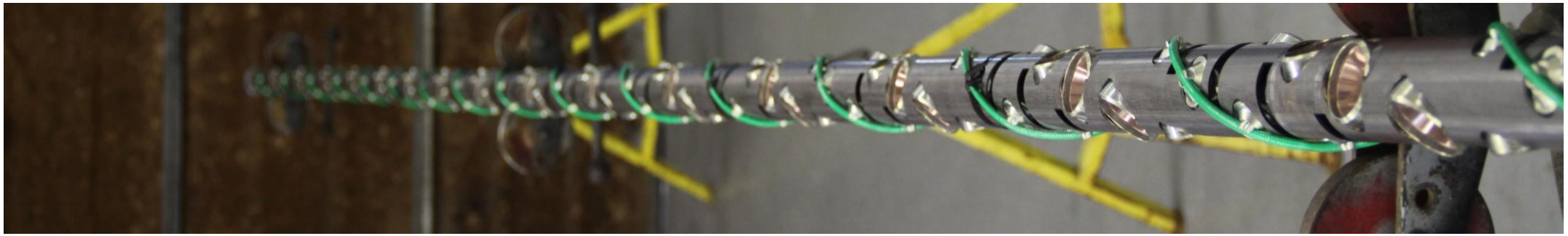
- Pre-job evaluation of the system
  - A number of flow laboratory experiments were conducted to compare the influence of the propellant application on tunnel clean-up and productivity
  - System-level qualification tests were conducted to check the gun swell and survivability of the system

Without propellant



With propellant



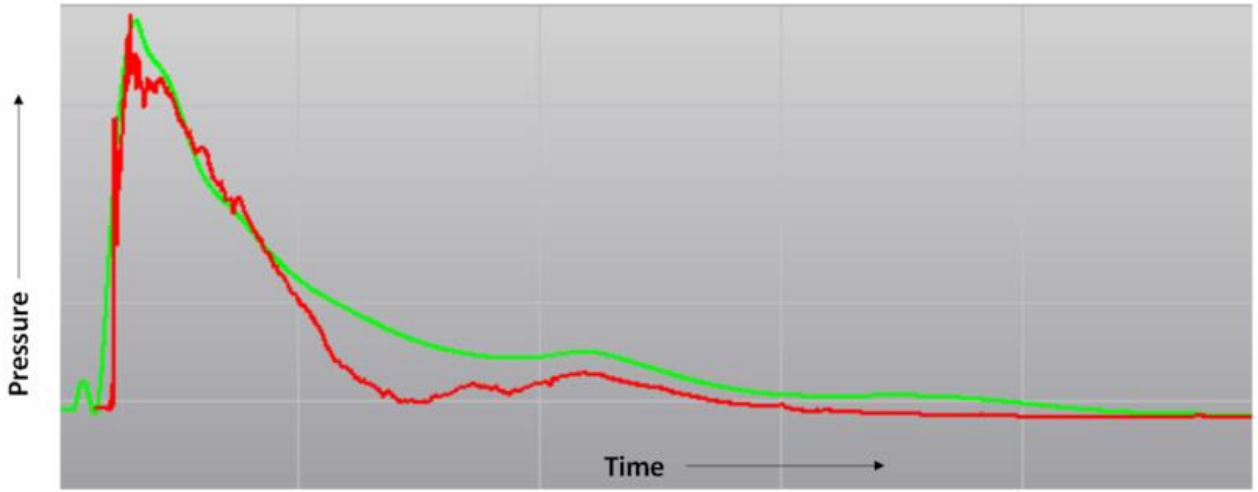


CASE-HISTORY

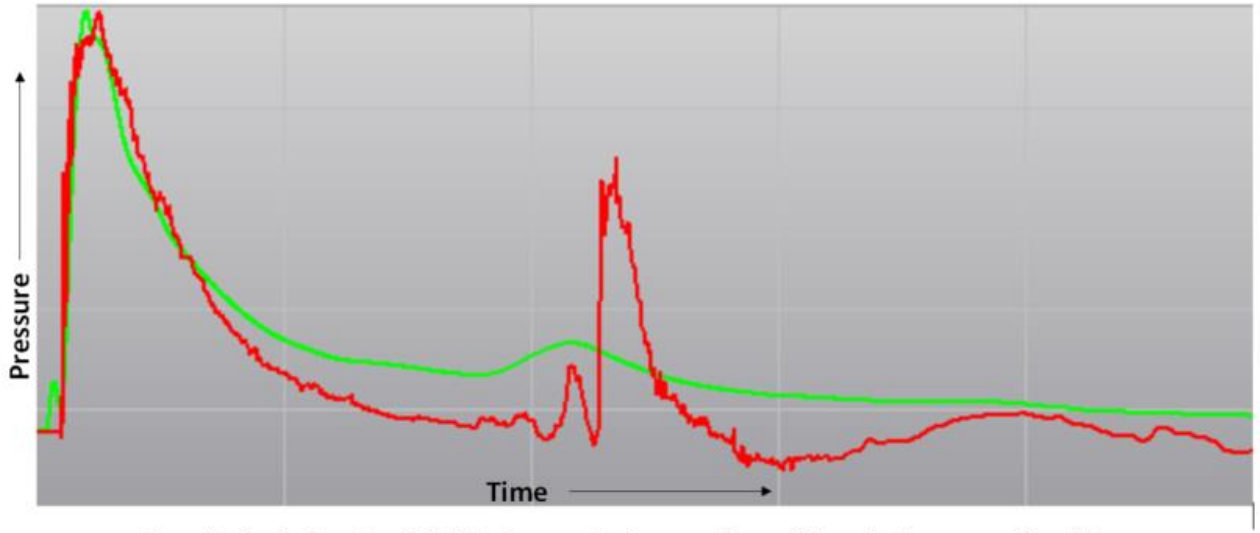
INTERNAL PROPELLANTS WITHIN THE PERF GUN

- Pre& post job modeling of the system
  - Reservoir-driven charges combined with internal propellants were modelled.
  - A first-order, preliminary model was developed and calibrated using gage data obtained from the field.
  - Good comparison between the gage data and the computed data

First-ever successfully deployment of this system for the Middle East operator through careful testing/validation, pre and post job modelling and operational planning yielded positive results (increased productivity)



Gage (red color) and model data (green color) comparisons of transient pressure, Run # 1



Gage (red color) and model data (green color) comparisons of transient pressure, Run # 2

QUESTIONS?
THANK YOU

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