Refracture for Improved Production

INTRODUCTION

Horizontal drilling was introduced to the industry in late 80's. In March 2010 horizontal drilling (HZD) surpassed vertical/directional and in October 2016 HZD surpassed 80% of the drilled wells. Current numbers show HZD accounts for ~88% of drilling in the US.

While fracturing has been around since about 1949 there have been many changes in fracing types. There have been changes in fluid types (gelled oils, gelled acid, linear and crosslinked fluids, energized-foamed fluids, acids, N_2 and CO_2, slickwater, etc.) and proppant types (sand, man-made ceramics, glass beads, etc.).

Initially, vertical well principles (best known practices) were applied to horizontal wells. But fracture models, theories and beliefs were biased by the great successes of vertical well fracturing in conventional rock. Many of these treatments are now believed to be less effective and left under stimulated pay intervals in the lateral.

While there have been 1,000's of re-fracs already performed and numerous papers written on their successes. Many of these show sharper declines in production and lower EUR's (Estimated Ultimate Recovery) when compared to projections.

Moreover, modified processes have the ability to improve profits and EUR's and many studies have shown that the better the initial production is the better the refrac will be.

DISCUSSION

There is a large opportunity within our industry for success and improvement utilizing current wellbores. There are approximately 910,000 active oil and gas wells in the US (35 of 50 States). This is not a replacement for new drilled wells (or is it?) and parent/child well interactions need to be considered.

CANDIDATE SELECTION

Candidate selection is the most critical portion of determining if a well is a refrac candidate or not. Many aspects and considerations need to be looked at in order to select the best wells for recompletion. Below are a few items that are reviewed:

1. Early phases of the horizontal completions
    a. Vertical well fracture techniques (Note: vertical wells can be candidates as well)
    b. Perforation clusters and numbers
    c. Improper fluid usage
    d. Treatment type not optimized for reservoir type
    e. Poor completion practice
    f. Could have good production (EUR)
    Note: Normally wells with best production have better refrac response

2. Wells with lower than forecast EUR values
    a. Lower depletion due to low production
    b. Increased SRV (stimulated reservoir volume)
    c. Current wells with latest/modern completion techniques are outperforming previous wells in the area
3. Casing size and condition

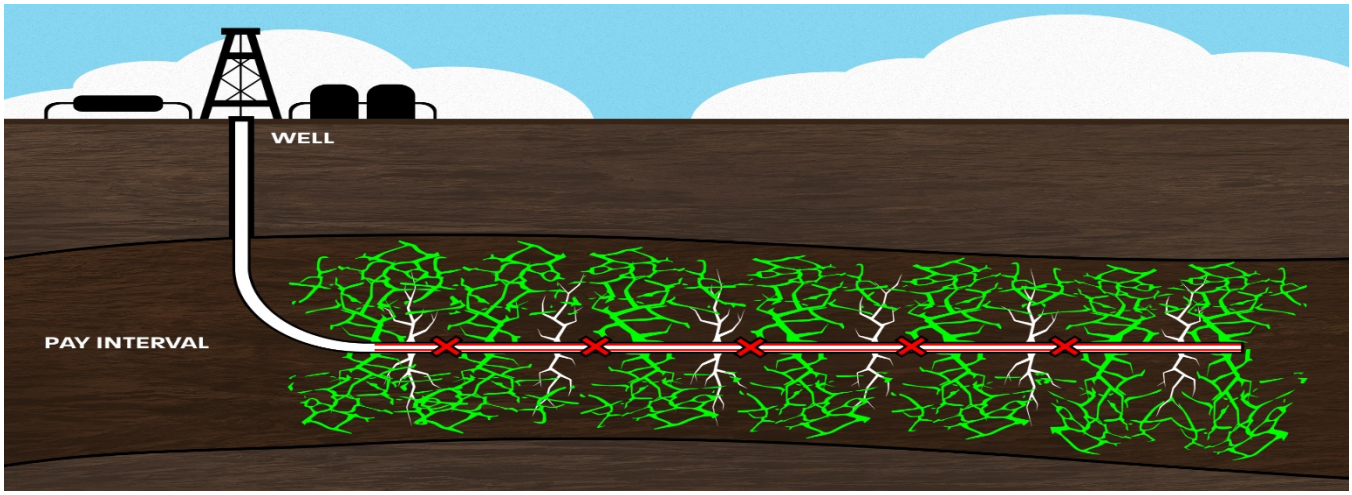
OTHER POTENTIAL UPSIDES FOR REFRACTURE TREATMENTS

It eliminates current permitting issues for new wells such as in Colorado, BLM, and State and local municipality. It provides opportunity for new startup companies. Property sales, acquisitions and mergers are also benefited.

GOALS FOR SUCCESSFUL REFRACTURE COMPLETIONS

A re-fracture treatment needs to get past or enhance old stimulation and tie into new un-produced areas. This can be done by the following:

- Stimulate same area but gain more interval
- Isolate old area and redirect stimulation to cover new area
- Combination of both
- Replace lost fractures



REFRAC METHODS

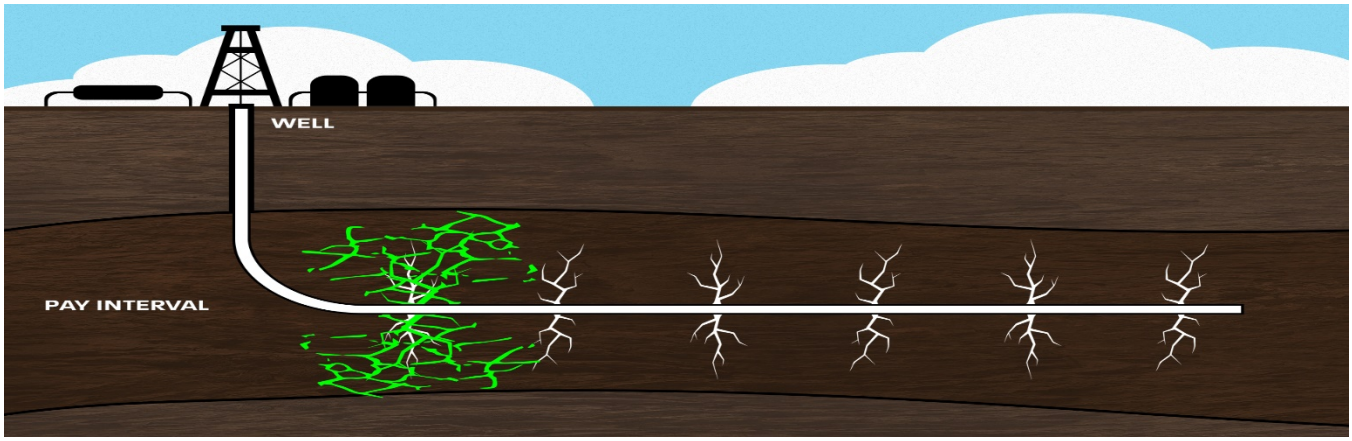
(IN NO PARTICULAR ORDER)

1. Single (Large) Treatment of Current Wellbore

Perform a bullhead treatment on the existing well with no changes downhole.

- PRO'S:
  - Easiest and cheapest method
  - Have seen some production increases that paid for refracture

- CON'S:
  - Least effective in covering entire horizontal
  - Will go to least restrictive area only (highest drawdown)
  - May yield minimal to no increase in production
  - Extension past heel/curve (~30%) is primary challenge

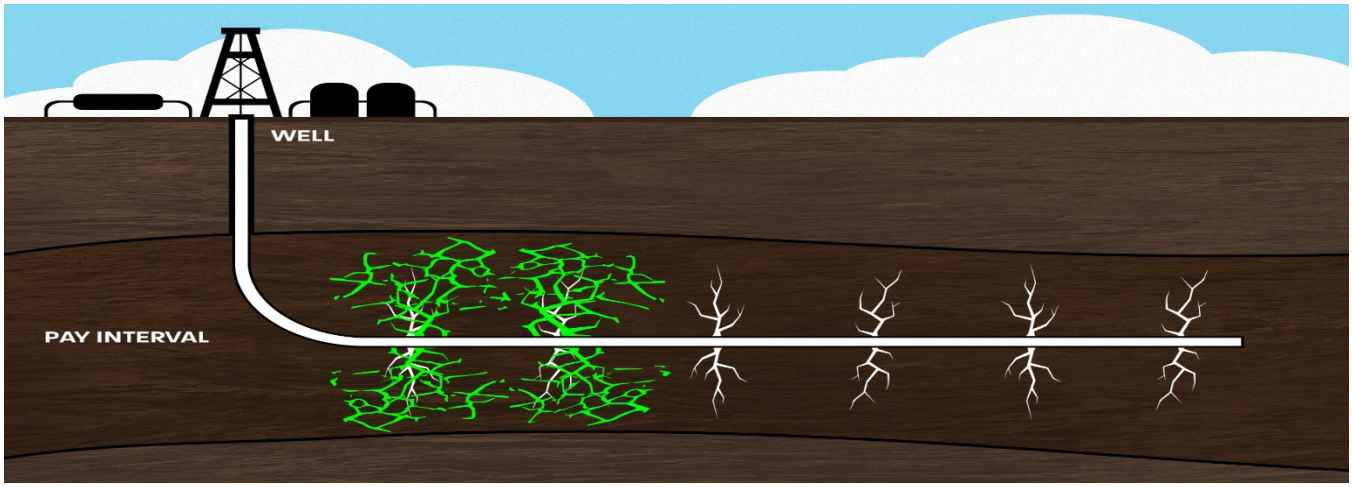


2. Stage Frac with Diversion of Current Wellbore

Perform a treatment on the existing well with no changes downhole but implement diversion in an attempt to cover a larger area.

- PRO'S:
  - Minimal preparation costs to get well prepared for treatment
  - Improved coverage compared to the single treatment with no diversion

- CON'S:
  - May not cover the entire horizontal length due to inefficiency of the diverting mechanism. - NOTE: Ask About the New IPT Technique to Maximize Efficiency



3. New Diverter Technique

Clean out wellbore ensuring no restrictions to move to toe of the well and pump diverter down to isolate all current perforations. This will provide a wellbore where you can utilize coil tubing and add perforations for stage 1 and then treat the wellbore like a new well. It will perform plug and perf treatment moving up hole and adding new perforations.

Original treatment had excessive spacing, under-stimulated or both.

Excessive stage spacing causes:

- Current perforations can be temporarily or permanently squeezed off (isolated)
- Tubing conveyed gun used for first refracture perf sets and followed by standard plug and perf for remaining sets
- Temporary Squeezing of the old perforations to the point of complete screen out for isolation

Diverter type:

- Biodegradable thermoplastic made from organic sources
- Nontoxic and nonhazardous, compatible with acids, brines, etc.

Diverter selection is driven by:

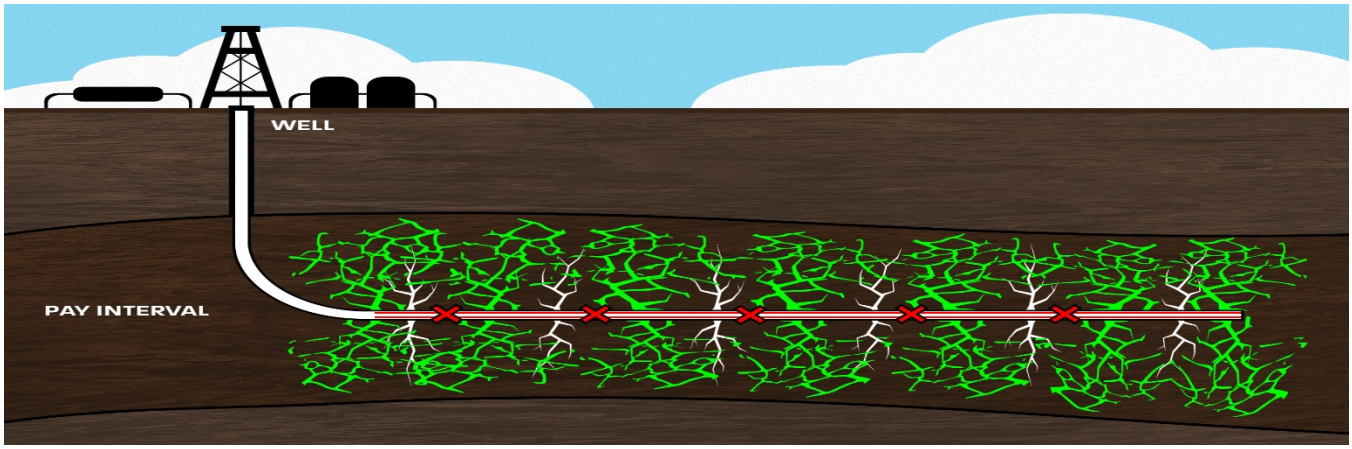
- Desired lifespan
- Pressure needed for diversion to hold
- Transport of diverter (rate, tubulars, etc.)

➢ PRO'S:

- Minimal preparation costs to get well prepared for treatment
- Improved coverage compared to the single treatment with no diversion

➢ CON'S:

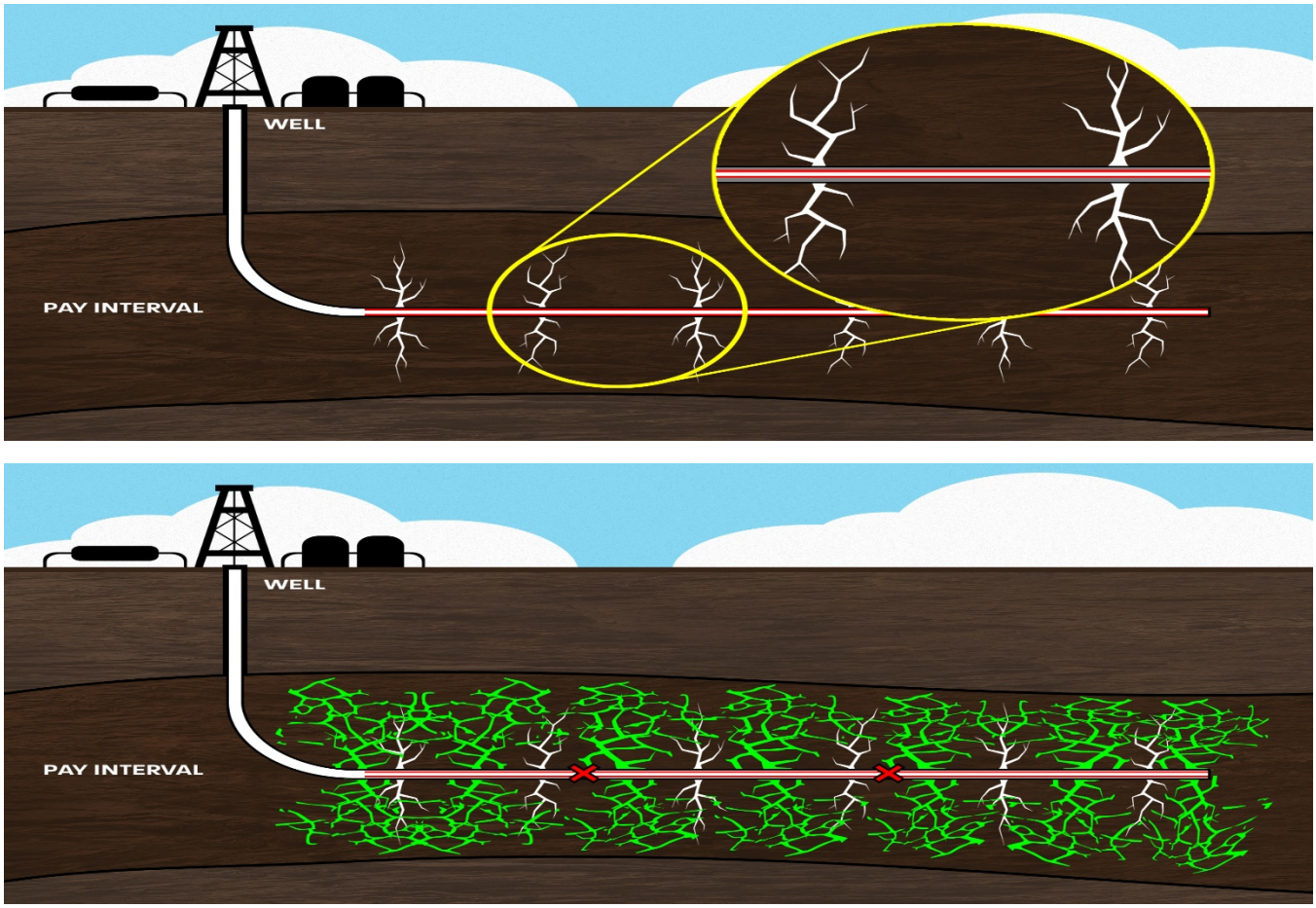
- May not cover the entire horizontal length due to inefficiency of the diverting mechanism
- Question on running plug and perf past so many squeezed off perforations (can run more diverter)



4. Full (Smaller ID) Internal Liner Isolation

Install smaller ID liner in the current well and cement in place for isolation and treat like a new well with 2 casing strings.

- PRO'S:
  - Most effective method to isolate entire horizontal if applicable
- CON'S:
  - Install smaller ID liner in entire horizontal section
  - Largest liner ID to optimize (wireline, rate, completion work)
  - Cement
  - Ability to set full liner (difficult completion)
  - Cost of liner (cementing or external packers)
  - Cement loss to formation

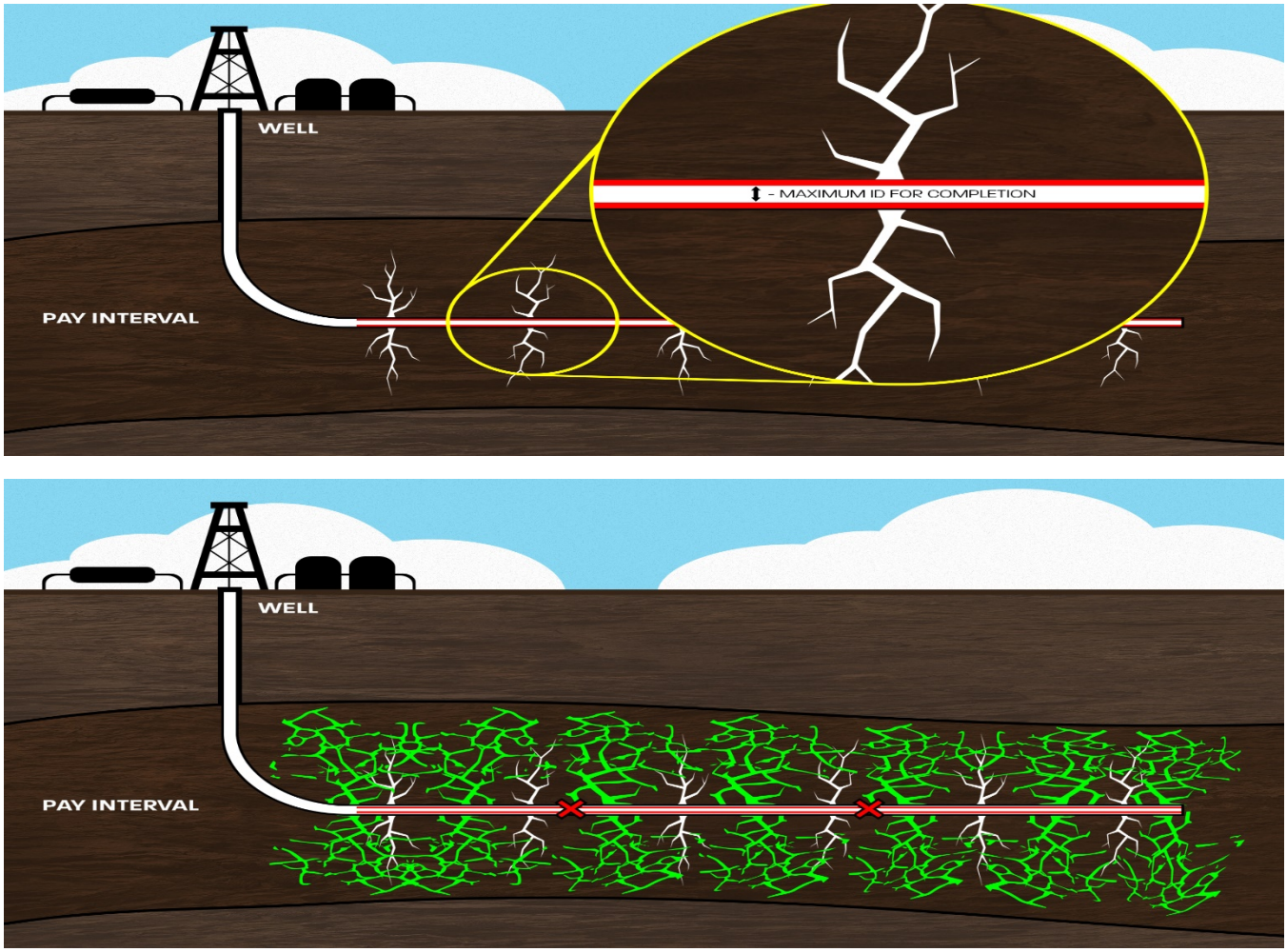


5. Casing Patches or Scab (Expandable) Liner

Isolate old perforations with an expandable liner

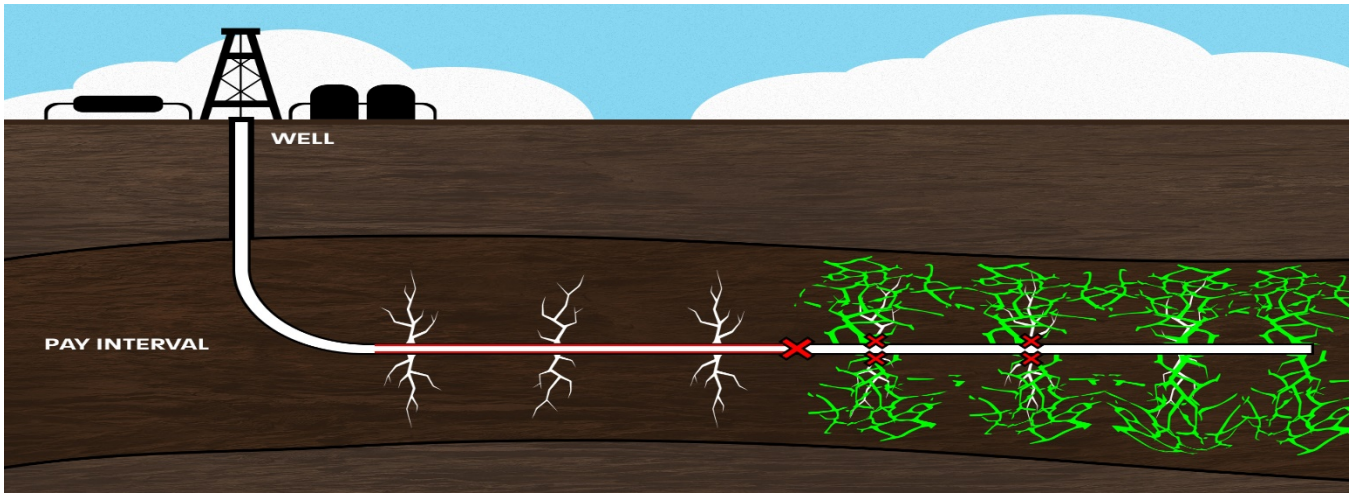
- PRO'S:
  - Effective in isolating portions of the horizontal
  - Permanent replacement and isolation
  - Gives maximum ID for remedial work (ROT lose ½" from original casing ID)
  - Higher achievable frac rates due to minimum loss in ID
- CON'S:
  - Cost (~$100/ft for patch installation costs, $200,000 for 2000')
  - Liner preparation (clean out, etc.)
  - May require specialty tools (plugs, mills, etc.)
  - Inability to run 1 liner past 2500-3000' (multiple liners?)

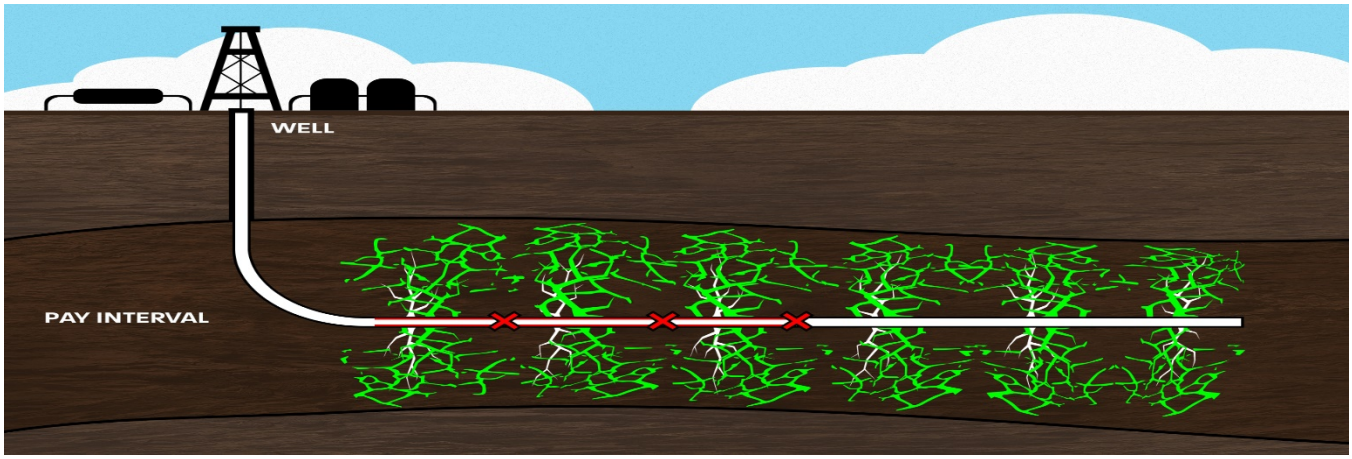
- Some evidence of difficulty in running multiple liners



6. Combination

Contact IPT for discussions of more than one method being utilized at a time for added success and minimizing costs.





7. Pinpoint (Coil tubing)

IPT is not currently recommending this method due to the inherent risks involved with coil tubing and many open perforations on the backside when isolating for a treatment. It is an option if full isolation can be achieved or on a new well.

FRACTURE DRIVEN INTERACTIONS (FDI) – FRAC HIT

Minimizing offset fracture interactions is critical when performing refrac treatments.

Mitigation Options:

- Completion Strategies
  - Diversion – Far field and NWB (reduce fracture length-Xf)
  - On the fly changes (Stop if see communication)
  - Infill smaller treatments (reduced Xf)

  - Pinpoint fracs (Coil tubing) (reduced Xf)
- Depletion Mitigation Options
  - Small Preload
  - Large Preload
  - Refrac prior to frac infill (Defensive Frac)

CONCLUSION

- Large number of candidates
- Previous completions not optimized
- Candidate selection is critical

HOW IPT HELPS

- Works with client to help determine the best candidates
- Analyzes chosen candidate and helps optimize re-completion
- Clients' expert on location (your goals and success are ours)
  - Personnel experience, training and support
- Has Performed 1000's of stages per month across the country
- 100's of clients and work with every Service Company
- Cost control with optimized stimulation onsite:
  - Realtime pressure analysis to optimize stimulation
  - Realtime changes in design to reduce chemical, time, etc.
  - Stage and NPT tracking (eliminates surprises at end of well)
  - Field and final invoice review
  - Savings normally larger than cost of IPT
- Treatment documentation (excel, digital ascii data, etc.)

IPT has many examples of successful and non-successful refrac treatments that will help your project to succeed. Contact us for questions or to setup an in house or Team meeting of re-fracture completions for improved production.