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Golden Rules of Minifrac Tests: Part 1 - General and Operational Rules

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The purpose of this short article is to address some of the most important general and operational rules of a minifrac test for unconventional reservoirs. It is intended for people new to the field. The following is not meant to be an exhaustive list and does not cover step-up or step-down combinations with a minifrac test.

1. **Wellbore Conditioning**: Fill wellbore with a liquid (see#4) and make sure that wellbore and surface lines are properly purged and are cleared of any gas bubbles.
2. **Recorders**: Use calibrated recorders with per second resolution. Record both pressure and rate data. Downhole gauges are recommended over surface ones.
3. **Wellbore on Vacuum**: Be prepared for a wellbore vacuum encounter during shut-in period by installing a downhole shut-in tool (e.g., Wireline Retrievable Bridge Plug) and set pressure gauges below it.
4. **Fluid Type:** Inject a low viscosity Newtonian incompressible fluid (typically low salinity water or oil) that is clean and compatible with formation. For a high permeability[1] reservoir, consider injecting liner-gel to control the leak-off; avoid gelled fluid[2]. Never inject slurry for a test!
5. **Pre-test:** Make sure all ports are open and run at least an hour of leak-off test (when possible, run it longer) prior to minifrac test. A leak-off test can be used to rule out any wellbore integrity issues and gives an estimation of system permeability.
6. **Injection Time:** Once breakdown occurs, inject for 3-5 minutes. For a high permeability[1] reservoir, injection time can be extended to 10-15 mins.
7. **Injection Rate:** After breakdown occurs, inject at a maximum constant rate possible (typically 1±0.5 m^3/min for practical reasons). If not planning a step-down test (it could mask closure pressure signature), stop pumping instantly and close all wellhead valves. Do not rig out pumps at least for an hour (longer is preferred when possible) to avoid interfering with fracture closure.
8. **Closure time:** Closure time is proportional to fluid leak off rate into formation. Therefore, it is a function of injection time and system permeability (assuming fracture volume to area is constant). See table 1 for the order of magnitude closure times.
9. **Pore Pressure:** Pore pressure should be estimated from a pseudo radial flow regime (see #10). If pseudo radial flow is not established, formation pseudo linear flow can be used but it would give a less reliable (optimistic) estimation of pore pressure. See table 1 for time to establish transient linear flow regime.

[1] High permeability reservoir: k≥O(100 md).

[2] Gelled fluid could cause filter cake issue and would prevent pressure communication with reservoir.

10. **Permeability**: System permeability (reservoir transmissibility: k h/μ) can be estimated only if pseudo radial flow regime is established. Therefore, longer data collection is a key when practical. Estimated system permeability would be correlated to production and most likely different than measured core permeability[1].

11. **Shut-in time:** Shut the wellbore in as long as practical and record pressure data. See table 1 for shut-in time (order of magnitude) required to establish pseudo radial flow regime for a proper system permeability estimation**.**

Table 1: Time (order of magnitude [a]) to establish different events in a minifrac test

Event	***Milidracy rock***	***Microdarcy rock***	***Nanodarcy rock***	*Comments*
Fracture Closure Time	***O(Minutes)***	***O(Hours)***	**O(Days)**	Closure is a progressive event!
Time to Establish Formation Pseudo Linear Flow	***O(Hours)***	***O(Days)***	**O(Weeks)**	Pore pressure can be estimated but less reliable
Time to Establish Pseudo Radial Flow (Recommended Shut in Time)	***O(Days)***	***O(Weeks)***	**O(Months)** [b]	Both pore pressure and system permeability (reservoir transmissibility) can be estimated

[a] Use it cautiously. For all cases, it is assumed that a low viscosity fluid is injected for no more than 5 min. A rock with a permeability on the order of Darcy most likely does not require a hydraulic fracturing treatment and is not discussed.
[b] In practice, pseudo radial flow may never get established.

Part 2 will be focused on the technical analysis and interpretation of a minifrac test. Part 3 will discuss potential problems and pitfalls in pressure diagnostics.

References:

1. Published material by Barree R. D. including but not limited to: Barree R. D. et al., 2007, Holistic Fracture Diagnostics, SPE107877.
2. Ziarani A. S., Islam A., and Hawkes R. V., 2014, "Minifrac Analysis in Unconventional Reservoirs", Poster, Trican Well Service.
3. Ziarani A. S., 2019, Minifrac Analysis Lecture Notes, PetroMars Inc.

[1] Stress, saturation, slippage effects (in case of dry gas reservoir) and the existence of natural fracture causes the discrepancy.