Choosing a Fracturing Fluid

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Many papers have been published concerning the planning and design of fracturing treatments. Most publishers have concerned themselves with proposed production increases, fracture conductivity, fluid coefficients and fracture area. This paper will point out the economics to consider in choosing a fracturing fluid.

Due to the generally low permeability reservoirs throughout the Permian Basin, and the increased efficiency of today's fluid loss additives, there is little difference in the calculated efficiencies of most water-based fluids versus oil-based fluids. At comparable volumes and injection rates, the fluid and spurt loss characteristics of either water or oil-base fluids can be manipulated to yield similar fracture areas.

With the advent of improved anti-swelling chemicals and non-emulsifiers, the choice of fracturing fluid is presently based upon total overall cost of treatment (i. e., cost of fluid additives, horsepower costs for comparable injection rates, etc.), and with many operators the availability and simplicity of obtaining the fluid. Viscosity or proppant-carrying ability is also an important aspect to consider in many areas.

COMMERCIAL BRINE

Commercial brine has been the most popular fracturing fluid for the past seven or eight years. It can be easily treated for non-emulsion tendencies, is compatible with most formations and, being a 10 lb/gal. brine, gives the greatest hydrostatic head of the general fracturing fluids—which means less horsepower requirements for equivalent injection rates. One of the areas where this fluid should **not** be used would be in a formation with a known high salt content. The super-saturated brine resulting in its use can precipitate dissolved salt, thereby plugging formation channels. Present commercial brine costs run about $0.15/bbl plus hauling. General treatment of brine consists of 20 lb guar (viscosity and friction reducing agent), 25 lb fluid loss additive, 5 lb buffer (to allow better gel yield), and 1/2 gal. non-emulsifier per 1000 gal.

FRESH WATER

Fresh water has been in greater use the past two to three years than for some time past. It is treated for non-emulsion tendencies as is the brine, plus treatment with a non-swelling chemical. The anti-swelling agent is usually either calcium chloride or potassium chloride in the range of three to ten lb per bbl. This makes a good uncontaminated fluid as the non-emulsifier used is also a bactericide, but the addition of the anti-swelling material will add from $0.18 to $0.80 per bbl to the cost of the fluid. Horsepower requirements will increase slightly with fresh water as the hydrostatic head will be about 15 per cent lighter than with the commercial brine. This difference is almost negligible except in deep wells or with high injection rate treatments. Fresh water costs about $0.05/bbl plus hauling. General treatment for fresh water is the same as that for brine with the exception of the buffer which can be omitted.

MODIFIED BRINE

Recently the use of a mixture of 40 per cent commercial brine and 60 per cent fresh water has gained favor. This mixture makes a 9 lb/gal. brine, is easily non-emulsifiable and gives a better yield from the gelling materials than does the saturated (10 lb/gal.) brine. Being lighter, this modified brine cleans up faster after treatment plus having less danger of becoming super-saturated in salt-bearing formations. The mixture is generally the most economical water-base fracturing fluid in use.

Another modified brine in use today is a brine made from fresh water with the addition of 1/2-lb/gal. of Carlsbad pink salt. This creates an 8-3/4 lb/gal. brine that is easily gelled, easily treated for emulsion tendencies, and may be advisable in areas where slight formation swelling tendencies are suspected. Cost per 1000 gal. will usually range about twice that of fresh water. General treatment for both brines is the same as for the commercial brine.

LEASE CRUDE

Lease crude can be the most economical fluid used provided that (1) injection rate, depth and size tubular goods are such that increased horsepower requirements do not offset the cost of other fluids (friction loss of lease crude is much greater than that of gelled water); (2) fracturability of the formation is such that the low viscosity of lease crude will carry the proppant; and (3) there is good assurance of recovering the load. Lease crude is usually recommended in extremely low bottom-hole pressure areas where any decrease in relative permeability may be an important factor. Normal treatment for lease crude is 50 lb fluid loss additive per 1000 gal.

GELLED LEASE CRUDE

Lease crude can be gelled to increase its viscosity and reduce its friction characteristics. The fluid becomes somewhat expensive (compared to the water base fluids), but the viscosity is three to four times that of straight lease crude and the gelled crude will have a 25 to 35 per cent reduction in friction loss. Generally gelled lease crude is for use in smaller tubular goods and where improved proppant-carrying ability is desired (over that of straight lease crude). Usual treatment is 25 lb fluid loss additive per 1000 gal.

REFINED OIL

Refined oil is a low gravity, high viscosity oil with excellent proppant-carrying capabilities and very good fluid loss characteristics when treated with a fluid loss additive. It is most expensive of the fluids discussed but very useful for low injection rate treatments. Horsepower requirements can become prohibitive at "normal" injection rates except in shallow wells or in large tubular goods due to its high friction loss characteristics.

TABLE I

Fluid	$/1000 gal	Hauling	Total
Commercial			
10 lb brine	$ 3.60	$ 4.80	$ 8.40
Fresh water	1.20	4.80	6.00
40% brine— 60% fresh water	2.16	4.80	6.96
Pink salt brine (1/2 lb/gal.)	5.60	4.80	10.40
Lease crude	—	4.80	4.80
*Refined oil	40.00	—	40.00

*Actual cost of refined oil is about $110.00/1000 gal. but resale upon recovery leaves a net cost of about $40.00/1000 gal.

COST COMPARISON

Since service companies refer to fracturing additives in units per 1000 gal., a cost comparison per 1000 gal. of fluid will be made. Present day average prices of fluids (without additives) and hauling costs are presented in Table I.

Additives vary with fluids, area and situations, but general concentrations to use for cost comparison based on similar, if not equivalent, fluid coefficients are shown in Table II.

TABLE II

Water Base Fluids	Lease Crude	Refined Oil
20 lb Guar (gelling material)		
25 lb FLA (fluid loss additive	50 lb FLA	25 lb FLA
5 lb Buffer		
1/2 gal. Non-emulsifier		

Table III shows cost of the various fluids, cost of the particular additives used in the fluids as shown above, and the total cost per 1000 gal.

TABLE III

Fluid	Cost	Additives Cost	Total Cost
10 lb brine	$ 8.40	$ 34.50	$ 42.90
Fresh water	6.00	38.82	44.82
40% brine— 60% fresh water	6.96	33.25	40.21
Pink salt brine (1/2 lb/gal)	10.40	33.25	43.65
Lease Crude	4.80	30.00	34.80
Refined oil	40.00	15.00	55.00

According to the above costs, a 60,000 gal. fracture treatment could be performed with lease crude at a $320.00 saving over any other fluid. Therefore, the difference in fluid and fluid additive costs is generally negligible compared to the total cost of a treatment; but horsepower costs can vary total treatment costs considerably.

Figures 1, 2, 3 and 4 show horsepower requirements for an assumed fracture treatment. Two wells; one 3000 ft deep with a fracture gradient of 0.854 psi/ft and the other, 6000 ft deep

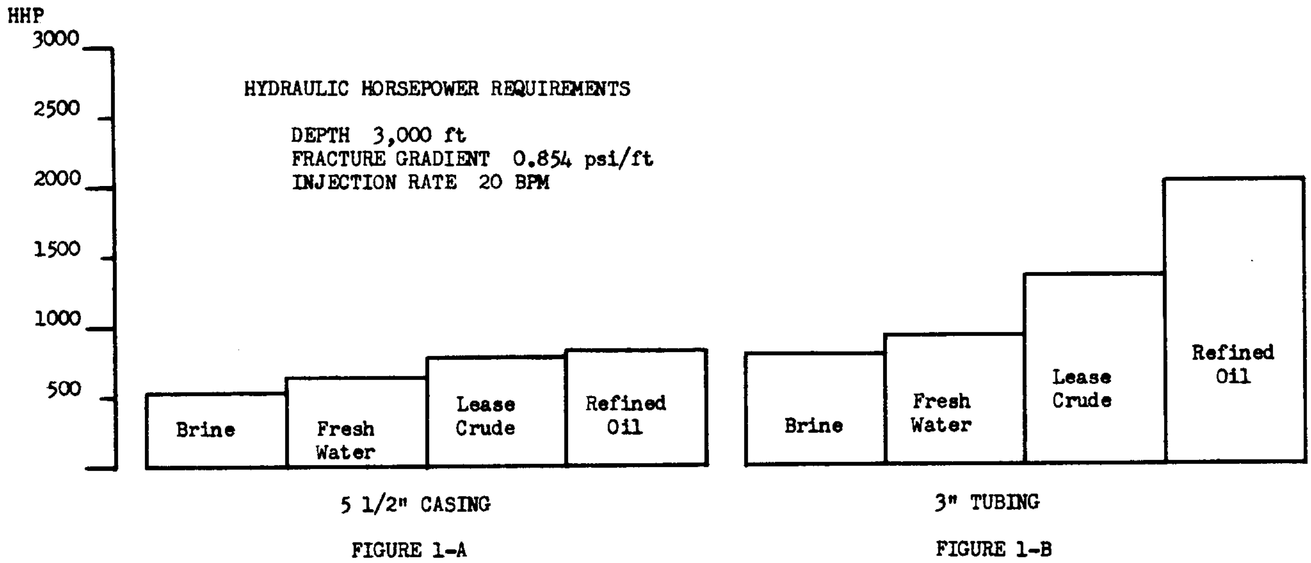

FIGURE 1

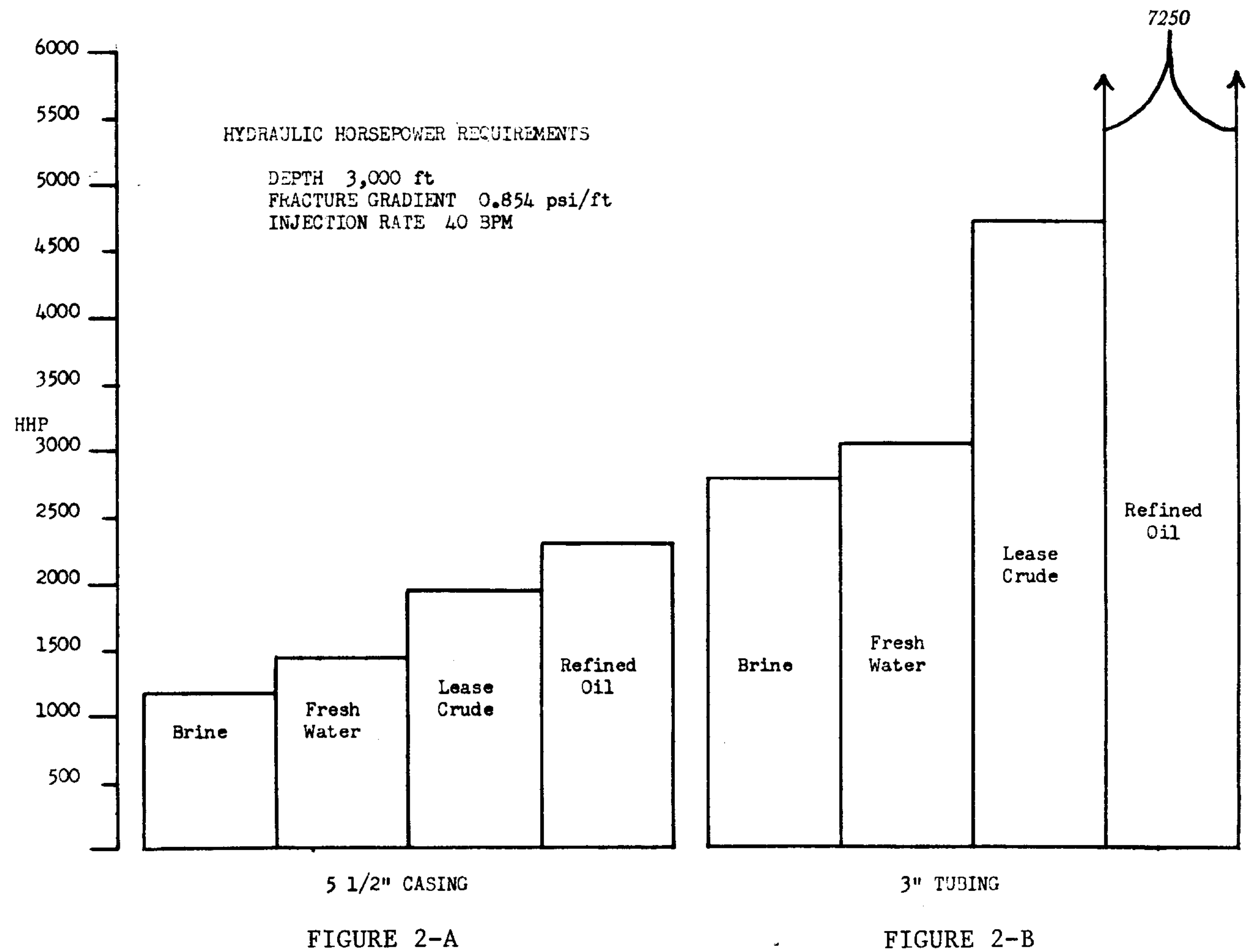

FIGURE 2

with a fracture gradient of 0.725 ft, are considered. The four fluids considered in each instance are (1) gelled 10-lb brine, (2) gelled fresh water, (3) lease crude, and (4) refined oil. Figures 1-A, 2-A, 3-A and 4-A are treatments down 5-1/2 in. casing. Figures 1-B, 2-B, 3-B and 4-B are based on treating the same well down 3-in. tubing.

Horsepower requirements do not vary greatly with fluids at low injection rates and large tubular goods (see Figs. 1-A and 3-A). Note that as the injection rate increases (Figs. 2-A and 4-A), or the size of the tubular goods decreases (Figs. 1-B, 2-B, 3-B and 4-B), the choice of fracturing fluid can have a great effect upon the overall cost of treatment due to the wide variance of horsepower requirements.

Some operators choose water-base fluids due to the simplicity of paper work—no tenders, permits or royalties to consider. Even in cases where lease crude may be more economical (i.e., shallow wells with large tubular goods), they choose water. Of course, water is also desirable from a safety standpoint.

One of the greatest arguments for water is that many formations require a certain amount of fracturing fluid viscosity to create sufficient fracture width to allow entrance of the proppant used. Refined oil will have the necessary viscosity, but its friction loss is so high that treating pressures may become prohibitive. With gelled water, sufficient viscosity can be obtained at an economical cost and the gelled viscosity **reduces** the friction loss, thereby reducing the total treatment cost.

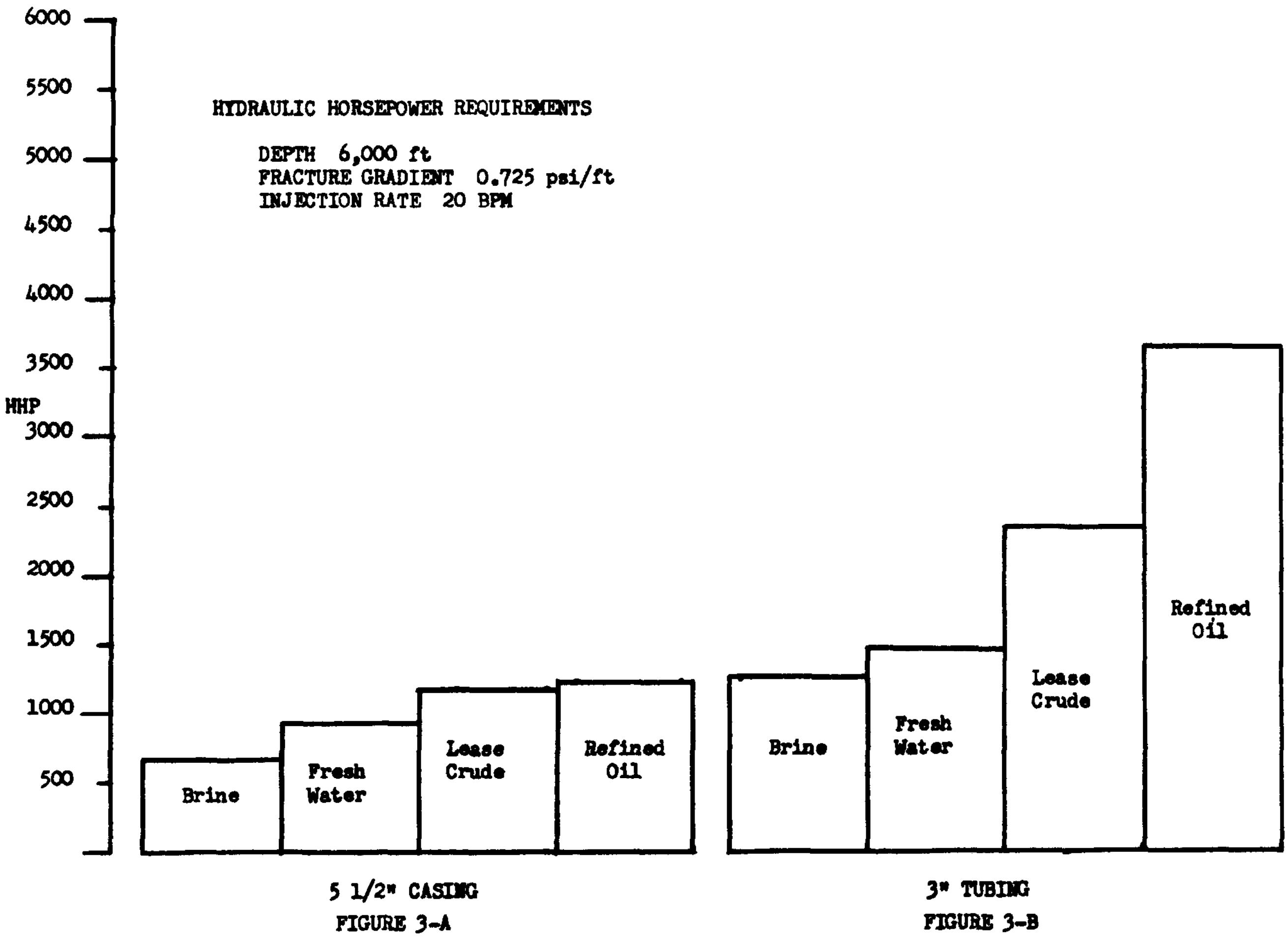

FIGURE 3

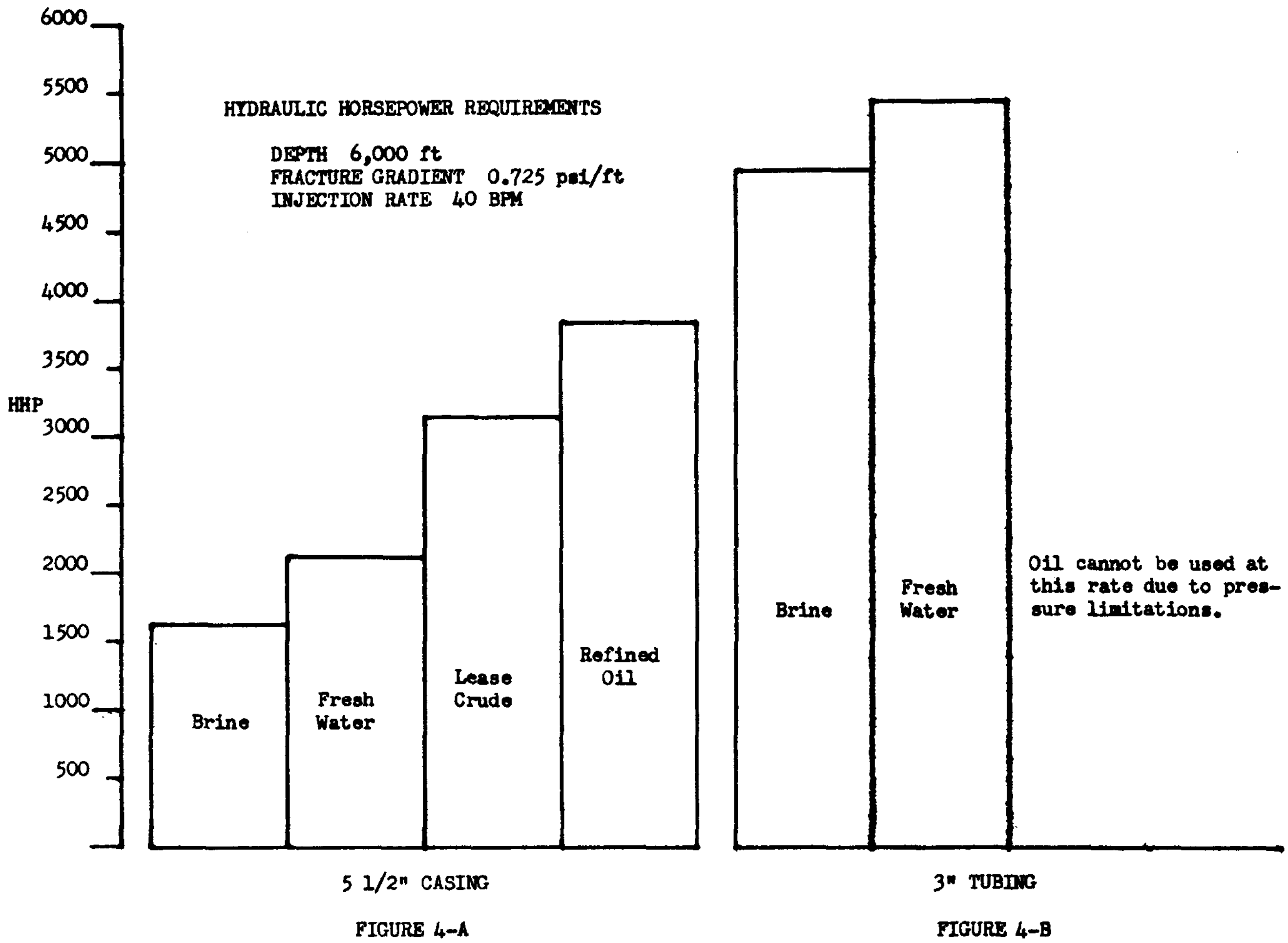

FIGURE 4

CONCLUSIONS

1. Based on calculated fluid coefficients in use today, there is little difference in created fracture areas using water-base or oil-base fluids with appropriate fluid loss additives.

2. The choice of fracturing fluid should generally be based upon horsepower requirements necessary to attain desired injection rates.

3. By careful investigation of friction pressure, hydrostatic heads, and fluid availability, an optimum fluid and horsepower requirement can be determined that will oftentimes same many dollars per treatment.

These conclusions are general in nature, as they should be. There are areas that cannot be treated with any fluid other than oil; some areas require greater viscosity than others, and some areas respond best to fresh water treatments. No "rule of thumb" should be used for planning stimulation treatments. A thorough investigation of each situation will yield better results and an overall saving of dollars.