Fac # 159262
API 045-07501

GM 14-36 Injection Testing Analysis

Analysis

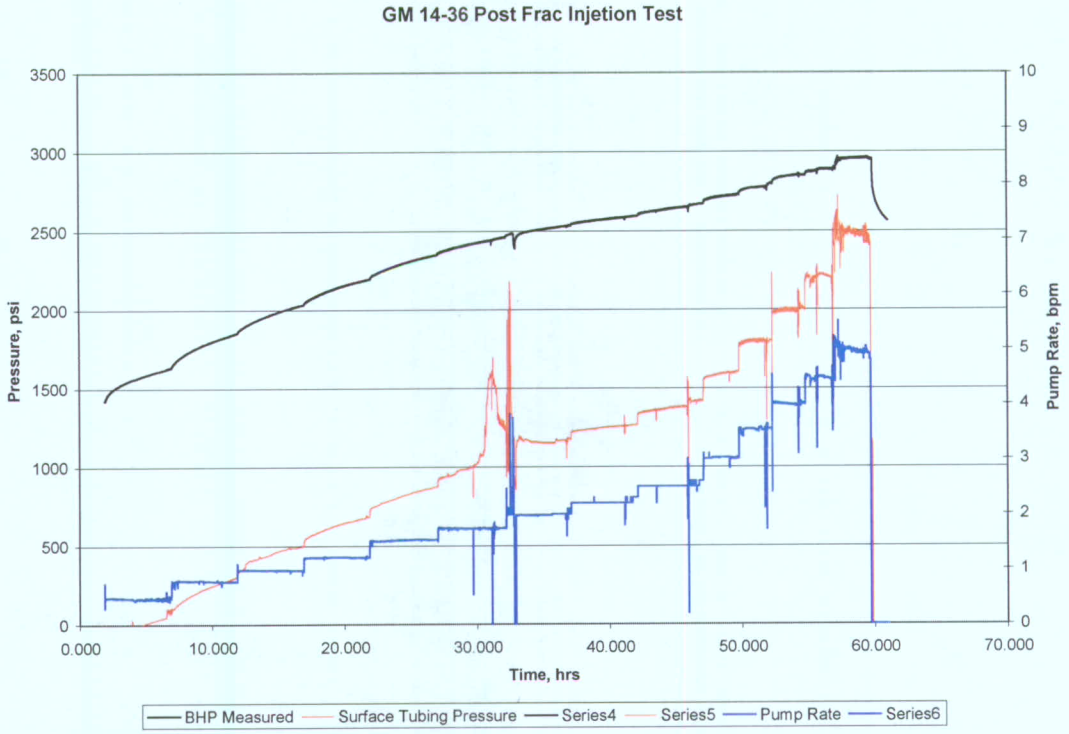
Following the hydraulic fracture treatment, a step rate test (SRT) was performed on the fractured interval. The perforations listed in Table 1 are shown on the log in Fig. 2 below.

Perf Top (ft)	Perf Base (ft)	# Holes	Diameter (in)
3,622	3,624	4	0.35
3,652	3,654	4	0.35
3,688	3,690	4	0.35
3,830	3,832	4	0.35
3,846	3,848	4	0.35
3,878	3,880	4	.035

Table 1

The SRT was recorded on surface and had a Bottom Hole (BH) Memory Gauge to record BH Pressure. The gauge was just below the packer during the test. The packer was set at 3,521 ft.

The treatment data for the SRT is shown in Fig 1.



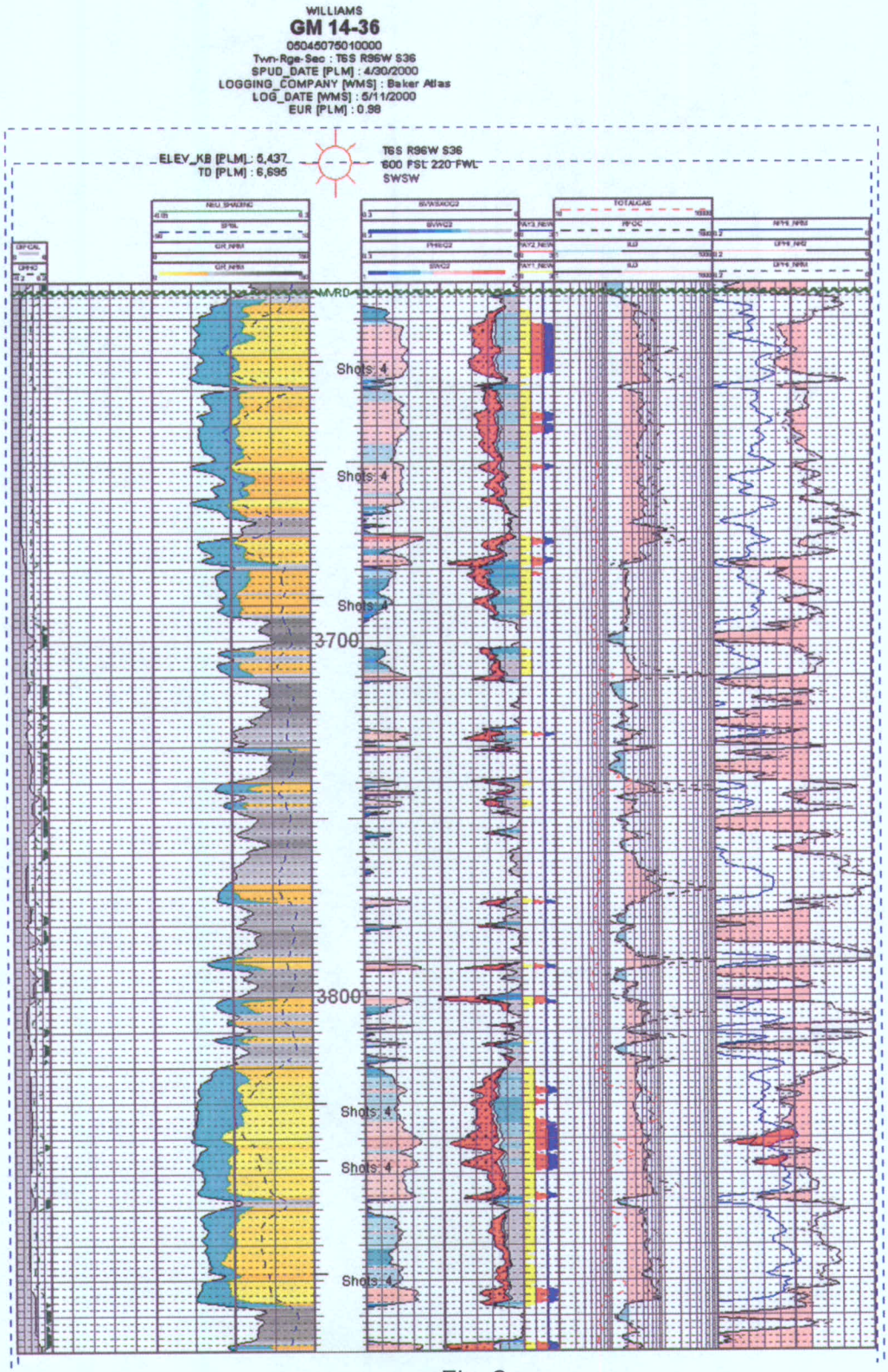

WILLIAMS
GM 14-36
05045075010000
Twn-Rge-Sec : T6S R96W S36
SPUD_DATE [PLM] : 4/30/2000
LOGGING_COMPANY [WMS] : Baker Atlas
LOG_DATE [WMS] : 5/11/2000
EUR [PLM] : 0.98
ELEV_KB [PLM] : 6,437
TD [PLM] : 6,695
T6S R96W S36
600 FSL 220 FWL
SWSW
MVRD
Shots: 4
Shots: 4
Shots: 4
3700
3800
Shots: 4
Shots: 4
Shots: 4

Fig. 2

A standard SRT analysis is presented below by plotting the rate of each step vs. the BH Pressure just before the next rate increase. Fig 3 shows the Pressure vs. Rate Plot.

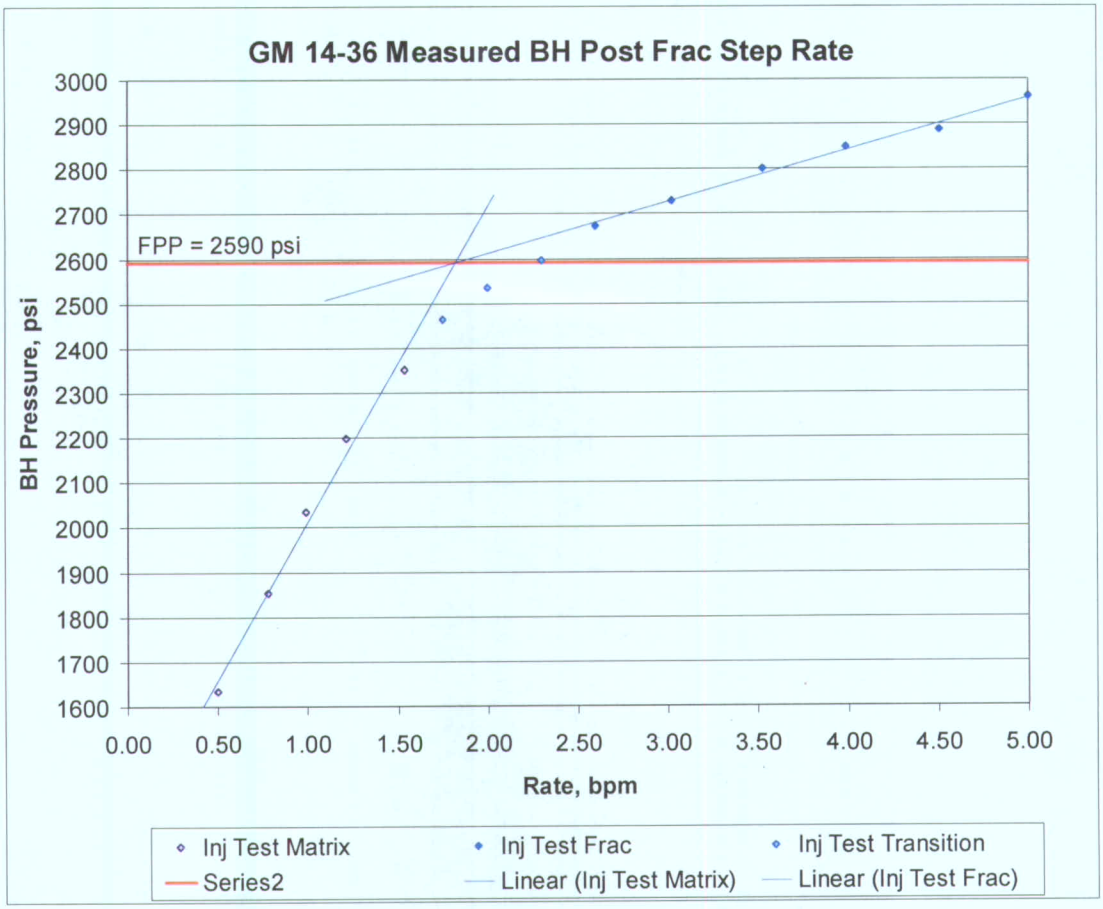


Fig. 3

A best fit line is projected through the group of low rate points and another is projected through the high rate points. The intersection of these lines defines the Formation Parting Pressure (FPP) which is the BH pressure above which the formation breaks down. The FPP is the upper limit on BH pressure for injection at matrix conditions.

The FPP for the injection zones is calculated to be 2,590 psi.

Using the top perforation of 3,622 ft as a depth reference, a fracture gradient of 0.715 psi/ft is obtained.

The use of the BH pressure gauge also showed high pipe friction even at low rates during the injection test. The pipe used was 2 3/8" 4.7# tubing. The friction pressures calculated are shown in Fig. 4. Hydrostatic pressure was calculated at the top perf of 3,622 ft and a fluid density of 8.43 lb/gal was used.

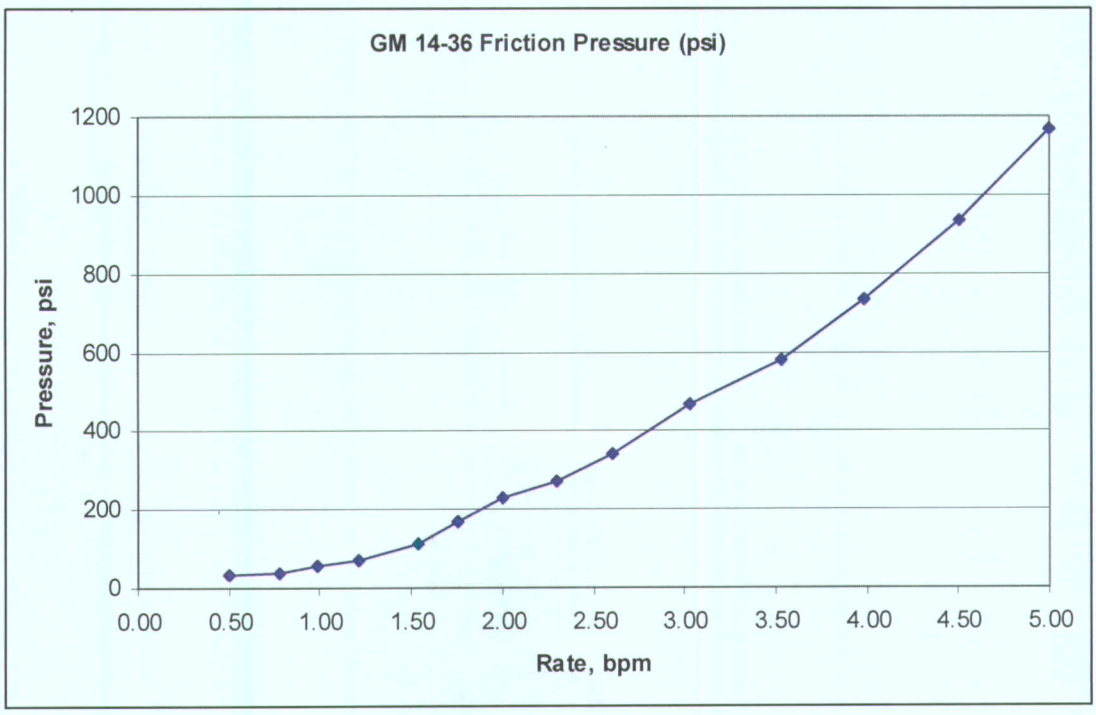


Fig. 4

Proposed Injection Pressures

Based on the SRT analysis and in consideration of the significant pipe friction pressures seen at low pumping rates, the following conditions are proposed to determine the maximum allowable surface pressure at various injection rates:

Max BH Pressure = FPP = 2,590 psi

Hydrostatic Pressure = 3,622 ft x 8.43 lb/gal x 0.052 = 1,588 psi

Max Surface Pressure = 2,590 psi – 1,588 psi + Friction at Rate

Max Surface Pressure = 1,002 psi + Friction at Rate

For example, during the SRT a BH pressure of 2,595 (close to our FPP) was measured at 2.3 bpm (3,312 bpd). The pipe friction was calculated to be 271 psi at 2.3 bpm. The max surface pressure at 3,312 bpd would be:

Max Surface Pressure = 1,002 psi + 271 psi = 1,273 psi

According to the testing results, the max injection rate would be about 3,300 bpd. Actual injection rates, however, would be subject to not exceeding the max surface pressure at any given injection rate when compensate for friction.