STANDARDIZATION OF TESTING AND REPORTING PROCEDURES IMPROVES STIMULATION DESIGN AND EXECUTION

John Adcock, Devin Brown and Daniel Gray, BJ Services Company

Cecil Parker, Conoco

Abstract

Acid and sand fracture stimulations are critical to economic production rates in many wells, particularly in the Permian Basin. Production rates from one well to its offsets often vary. The difference in rates may be due to the heterogeneity in the reservoir or due to the design or execution of the stimulation. Conoco and BJ Services jointly implemented a system to standardize testing and reporting procedures for Conoco's Midland Division. The goal of this system is to simplify post job evaluations, ensure that well files contain complete information and to continuously improve job quality. In addition the manual that was developed from this process will aid in training of new personnel and consolidate reference materials. This paper describes why the process was implemented, the types of information contained in the manual and how the process has improved stimulation design and execution.

Introduction

In January of 1994 Conoco and BJ Services formed an alliance encompassing the Continental United States and Gulf of Mexico. BJ Services and Conoco's Midland division have worked closely together to improve pumping service processes during the alliance. Early in the alliance, the processes were worked in small areas of the division (i.e. Farmington, SE New Mexico, Val Verde Basin, Texas Panhandle, and the Rockies). The problem was that as engineers moved from one area to another or as new engineers transferred into the division, the process was often different from the engineer's previous area. This caused a loss in productivity during the transition period.

Although BJ Services has standard practices in place, many of the processes had been molded to what the Conoco personnel in place requested. A team was formed to put together a Conoco / BJ Services standard practice manual that would be used throughout Conoco's Midland Division.

The manual, which is designed around BJ's standard practices along with Conoco's expected practices, has three primary uses. The manual insures the use of standard Quality and Safety procedures from area to area. It also insures standard collection and documentation of data for use in future design and evaluation. The manual will also aid in training of new personnel in both BJ and Conoco.

This paper covers the reason for the manual's development, the information contained in the manual, and how the manual has improved design and execution of jobs since it's development.

Reasons For Standardized Stimulation Practices

The main objective of stimulation treatments is to optimize the value of the well. Production as well as cost affect value and both deserve proper consideration to make the best decision on a path forward. Meaningful changes in stimulation design can be only accomplished where there is a clear, documented record of how the treatment was executed. Decisions in evaluating the effectiveness of a treatment on a well's performance are often not based on what actually happened during the treatment. Many times these decisions are based on what one thought was done or what one intended to do. There is enough heterogeneity in most reservoirs to make stimulation evaluation and optimization a challenge. Incomplete post job audits of additives and unnoticed and unrecorded variances in pre-job testing and job execution further compound the problem. These undocumented variances can occur for several reasons: inexperience, deviation from recommended practices, outdated reporting forms that do not capture all the critical data, and lack of uniform (not incorrect) testing procedures and equipment from area to area. The manual was designed to eliminate or record these variances.

Listed below is a short discussion of several situations that further explain the need for and benefits of standardized stimulation practices.

- Standardized practices ensure that critical tests are conducted and vital information concerning pre-job testing, treatment execution and post job audits are collected and documented consistently.
- Pilot tests in the lab are often performed with stock lab samples of additives. The actual additives to be used should be segregated from inventory and used to perform pilot tests with mixing fluid from location. These results should be on location while field tests are being performed.
- Tests such as crosslink time and foam half-life are dependent on the size of the mixing jar and shear rate. Others tests, such as breaker tests, are affected by the type of sleeve used on the Fann-35 viscometer. Standardized fluid testing procedures reduce variances in test results. These procedures include step by step instructions for each type of test and the equipment required.
- Standardized testing procedures provide a base line to infer fluid performance from treatment to treatment.
- Acceptable concentration limits for all additives need to be established by appropriate pre-job testing. With established limits, the correct decision can be made about whether to shut down or continue if additives are not pumped as planned. It also provides a basis for adjusting for such things as fluid crosslink times by varying buffer or crosslinker concentrations. Additive concentrations such as these should never be changed during pumping without proper pre-job testing to validate the consequences. If there appears to be a problem with fluid sample during the job, it is usually a sampling problem. Always validate the additive rates before making any changes. If the rates are correct, no changes should be made.
- If additive pumps and or flowmeters are not properly calibrated before the treatment, significant variations in chemical rates can occur that seriously affects the fluid's viscosity, leak-off control, and proppant placement. The additive pumps should be sized to operate well within the desired chemical rates. If the chemical rates are too small (less than 1 gallon per minute) for the additive pump, then consider diluting the product 1-3 times. Mechanical backups, such as sight

glasses or tank straps, should be used throughout the treatment to validate the flowmeter rates or control the additive rate in the event the flowmeter malfunctions.

- Incomplete post job audits of all additives make it difficult or impossible to evaluate the effectiveness of a treatment, especially on under-performing wells. Pre and post job tank straps and calculated additive totals should be verified. Variance between designed and actual volumes should be no more than 5%.

Contents of the Manual

The Conoco / BJ Services Stimulation Standard Practice Manual is currently comprised of eight sections. These sections are chronologically arranged to provide clear, concise requirements for step-by-step execution of stimulation treatments. The manual begins with a pre-job checklist and concludes with well flow-back and clean-up guidelines.

Section One of the manual is a one page Pre-Job Checklist. The checklist is divided into six sections. It begins with a tailgate safety meeting once the service company arrives on location. This meeting is designed to coordinate assignments and job rig-up.

Once the service company has prepared its equipment to pump the treatment, a joint safety meeting is held with all personnel on location. During this meeting the following topics must be addressed: Personnel Safety, Job Procedure and Pumping Pressure, Emergency Procedures, and Location Safety. Each of these topics are followed by a list of subtopics which are designed to be addressed in full detail and checked off once completed. After all the pre-job items have been checked off and all questions have been answered, both the Conoco and BJ Services supervisors sign the completed form, thus allowing the job to proceed.

Safety is the topic of Section Two of the manual. This section is a supporting document to the Pre-Job Checklist. It provides detailed descriptions of plans and procedures for each of the six topics composing the Pre-Job Checklist. Familiarity with this section of the manual can help eliminate questions in the event of emergencies.

Proper job execution begins with complete job planning. This is the focus of Section Three, Recommendation Contents. This section begins by stating the following. "Each stimulation recommendation will contain the following minimum sections: cover page, wellbore and reservoir information, fluids and proppants specifications and volumes, pump tankage and base liquid volumes, verbalized job procedure if warranted, tabular pumping schedule, calculations of estimated surface treating pressure and, when appropriate, fluid temperature (required for foamed and energized systems), itemized cost estimate and description of the products." Following this statement, each of the above items are addressed in outline form with a comprehensive list of requirements.

Section Four, Job Types, provides a means for standardizing pre-job fluids testing preformed both in the lab and in the field. Lab and field guidelines are provided in chronological order for linear and crosslinked water based systems as well as for crosslinked hydrochloric acid systems. By providing similar instructions to both lab and field quality control personnel, a high degree of consistency can be achieved in testing procedures, thus allowing more complete and competent evaluation of fluid system performance.

Section Five, QC Forms, provides the paperwork necessary to perform competent evaluations of various fluid systems. Page one of Section Five is the Quality Control Form Guide. This guide provides in a tabular format the forms required by each of the various fluid systems pumped by BJ Services for Conoco stimulation treatments. For example, any acid treatment ranging from neat acid to foamed acid to crosslinked acid will require the completion of the Acid Based Frac Fluid Form (Fig 1). While a crosslinked acid treatment would subsequently require the completion of the Breaker Tests Form (Fig 3). Examples of the five types of forms are given in the appendix as Figures 1 through 5.

Section Six focuses attention on Fluid Systems specific to BJ Services. The objective is to provide a general description of each fluid system along with the various components of the system. Characteristics induced by chemical reactions are also included in this text.

Section Seven, Post Treatment Report Requirements, specifies what data will be recorded and how it will be organized and stored. From the information specified in this section, the execution and quality control measures of a treatment can be completely evaluated.

Section Eight serves as a catch all, and is appropriately titled Reference Materials. Any materials which do not serve as guidelines, but as requirements for job evaluation, proppant selection and analysis, quality assurance requirements for gels, crosslinkers, and buffers, hydration charts, rig-up and pumping of energized fluids, and flow back of energized fluids are included in this section.

The first topic found here is the Job Quality Improvement Guidelines worksheet. This worksheet provides post-job specific questions and concerns to be answered by Conoco and BJ Services supervisors. It is the intent of this worksheet to induce critical evaluation of job performance and provide focus on areas of improvement for future jobs.

Proppant sieve analysis and proppant distribution is the second topic found in Reference Materials. Instructions are outlined for performing a sieve analysis as well as determining particle distribution and allowable variances. Tables for conductivity and permeability for each proppant also accompany the particle distribution tables.

With the advent of liquid gel concentrates and the ability to pump treatments "on the fly" comes the need for greater quality assurance of chemical bases. The third topic of Reference Materials defines the variances allowed in gels, buffers, crosslinkers, and base gel viscosity in order to achieve proper fluid performance.

The pumping of carbon dioxide and nitrogen gases is a common practice in many of the fields in the Permian Basin today. It is the objective of the fourth topic in the Reference Materials section to make this practice as safe as possible for all personnel on location. Due to the complexity of this topic, the requirements outlined by BJ Services Standard Practice Manual have been adopted for this section.

With load recovery serving as the primary reason for pumping energized fluids, it is imperative that a well be flowed back in a fashion that will produce the most benefit to the operator while continuing to provide as safe work environment. It is the mission of topic five to provide such an environment by outlining procedures and surface equipment selections.

Improvements in treatment design and execution

Following the recommended practices that were developed from this process improves the design process and execution of stimulation treatments in several ways. Well files will contain complete and easily accessible information about each treatment. Post audits of a stimulation program are simplified with this process, allowing improvements and design changes to be made to the remainder of a program or to future programs. The manual that was developed from this process contains testing procedures and reference materials that aid in the training of new personnel. The amount of testing of a system can be reduced because information can be shared between areas when standard testing procedures are used in all areas. Most importantly, one can be assured that all of the proper quality control has been performed before every treatment.

Many times an audit of a stimulation program is performed after part of the program has been completed. From this data improvements to the design of the treatments are made if necessary. Many times the data from past treatments is available, but is not easily accessible. The data may not be stored in a single place or is not organized or complete. For instance, there may be a record of the volume of a product that was pumped, but not the rate. Pumping the right volume of breaker does no good if it was all pumped in the first half of the job. These procedures require that all data is recorded and stored in a manner that it can be easily evaluated at a later date.

Engineers and technicians must understand how to run tests properly and which variables are critical to the success of stimulation treatments. As personnel are promoted or moved into new positions, tools must be available to train them. The manual that was developed from this process contains information that will aid in these efforts. The manual contains proper testing procedures, recommended additive loadings for every type of fluid system and a reference section with information about individual additives, proppants and useful "rules of thumb". In addition to training new personnel, if one is unfamiliar with a system, all of the necessary information about quality control can be easily located.

While the procedures outlined in the manual require the highest level of quality control, following these procedures can actually reduce the amount of testing required. Small variations in the methods used to test fluid systems can change the results. If tests are run with consistent methods in an area, the results can be used from one job to the next. However, if tests are run with consistent methods in all areas, the database becomes much larger and fewer tests must be run to develop a system.

Small variations in additive concentrations can change the characteristics of the fluids. This is particularly true at elevated temperatures. In some cases the success or failure of a treatment can be attributed to one small variable that was or was not checked. Full records of every variable help one to determine whether pressure responses during the treatment and production results are due to the fluids or the reservoir. This analysis is critical to making improvements to future treatments.

Summary

A need was recognized to standardize testing and reporting procedures in order to improve total job performance. A manual was developed to outline critical parameters and reporting procedures. Implementation of this manual has assured the use of standardized procedures throughout the alliance.

Acknowledgements

The authors of this paper would like to thank BJ Services Company and Conoco for their support and permission to publish this paper. The authors would also like to thank Donald Blair, Roy Burgess, Loren Diede, Greg Vick, Dave Mack and John Willingham for their help in writing the manual that was the basis for this paper.

Gelled Acid Pilot Test	Notes:	
_____ cps	Customer:	Service Contract No:
	Well Name:	Date:
@ _____ °F	Formation:	Fluid Tech:
	Customer Signature:	Signature:

Base Acid									
Tank	Water	Raw Acid	Raw Acid	Design	Titrated	Iron	Begin	Ended	Pumped
No.	Volume	Volume	Be'	%	%	ppm	Volume	Volume	Volume

Gelled Acid				XL Acid				
Test No.	Gel Loading	Viscosity @ 511 -1	Temp °F	XLA-2 Loading	FE-300L Loading	XL (close) sec	XL (crown) sec	XL (Rel.) sec

Inventory - Additives Used								
Product								
Units	gals/lbs	gals/lbs	gals/lbs	gals/lbs	gals/lbs	gals/lbs	gals/lbs	gals/lbs
Loading								
Gel Volume								
Beginning								
After Loading Hoses								
Ending								
Used								
% Variance								

Figure 1 - Acid Based Frac Fluid Quality Control Form

WATER BASED FRAC FLUID QUALITY CONTROL

LFC Type ——
LFC Specific Gravity: @ °F
LFC Loading (gpt) : _____
Pilot Test Base Gel Visc: cps
@ °F

Mg = 0.243 x (Tot Hardness - Ca)

Notes:

Customer: | Service Contract No:
Well Name: | Date:
Formation: | Fluid Tech:
Customer Signature: | Signature:

Base Water Quality Control

Tank No.	Strap Reading	Fluid Type	Fluid Temp	pH	S. G.	Chloride (ppm)	Iron (ppm)	Sulfate (ppm)	Hardness (ppm)	Ca (ppm)	Bicarbs (ppm)	Mg (ppm)

Base Gel Quality Control

Tank No.	gals/lbs	gals/lbs	gals/lbs	gals/lbs	gals/lbs	Temp °F	pH 0-14	Viscosit cps	Buffered pH	XL (crown) sec	XL pH

Tank Volumes

Tank No.	Fluid (bbls) Initial	Final	Used
TOTAL			

Sand Sizes Available

12/20	16/30	20/40	Wt. Ret.	% Ret.	Wt. Ret.	% Ret.	In T1	In T2
8	12	16						
12	16	20						
14	18	25						
16	20	30						
18	25	35						
20	30	40						
30	40	50						
Pan	Pan	Pan						
	TOTAL							

Inventory - Additives Used

Product / Units	gals/lbs	gals/lbs	gals/lbs	gals/lbs	gals/lbs	gals/lbs	gals/lbs	gals/lbs	gals/lbs	gals/lbs	gals/lbs
Loading											
Gel Volume											
Beginning											
After Loading											
Ending											
Used											
% Variance											

Figure 2 - Water Based Frac Fluid Quality Control Form

BREAKER TESTS

OPERATOR _____ DATE _____
WELL _____ DISTRICT _____
FORMATION _____ TECHNICIAN _____
COUNTY _____ SIGNATURE _____
DEPTH _____

SYSTEM _____

Test #				Test #				Test #			
Buffer Loading				Buffer Loading				Buffer Loading			
Crosslinker Loading				Crosslinker Loading				Crosslinker Loading			
Breaker Loading				Breaker Loading				Breaker Loading			
Breaker Loading				Breaker Loading				Breaker Loading			
Pre-XL pH	XL pH	Broken pH		Pre-XL pH	XL pH	Broken pH		Pre-XL pH	XL pH	Broken pH	
Time	Bob Size	Reading	Temp	Time	Bob Size	Reading	Temp	Time	Bob Size	Reading	Temp

REMARKS _____

Figure 3 - Breaker Tests Form

FOAM STABILITY TESTS

OPERATOR ____________________ DATE ____________________
WELL ____________________ DISTRICT ____________________
FORMATION ____________________ TECHNICIAN ____________________
COUNTY ____________________ SIGNATURE ____________________
DEPTH ____________________

SOURCE ____________________
LIQUID VOLUME ____________________
PUMP TIME ____________________

SYSTEM ● ________ F

TIME	FOAM VOLUME	LIQUID VOLUME

TIME	FOAM VOLUME	LIQUID VOLUME

TIME	FOAM VOLUME	LIQUID VOLUME

TIME	FOAM VOLUME	LIQUID VOLUME

REMARKS

Figure 4 - Foam Stability Tests Form

POST - JOB SIEVE ANALYSIS

OPERATOR ____________________ DATE ____________________
WELL ____________________ DISTRICT ____________________
FORMATION ____________________ TECHNICIAN ____________________
COUNTY ____________________
DEPTH ____________________

SAND TYPE ____________________ SAND TYPE ____________________
MESH ____________________ MESH ____________________

Sand Size			Sample No.	
12/20	16/30	20/40	Wt. Ret.	% Ret.
8	12	16		
12	16	20		
14	18	25		
16	20	30		
18	25	35		
20	30	40		
30	40	50		
Pan	Pan	Pan		
Total				

Sand Size			Sample No.	
12/20	16/30	20/40	Wt. Ret.	% Ret.
8	12	16		
12	16	20		
14	18	25		
16	20	30		
18	25	35		
20	30	40		
30	40	50		
Pan	Pan	Pan		
Total				

Sand Size			Sample No.	
12/20	16/30	20/40	Wt. Ret.	% Ret.
8	12	16		
12	16	20		
14	18	25		
16	20	30		
18	25	35		
20	30	40		
30	40	50		
Pan	Pan	Pan		
Total				

Sand Size			Sample No.	
12/20	16/30	20/40	Wt. Ret.	% Ret.
8	12	16		
12	16	20		
14	18	25		
16	20	30		
18	25	35		
20	30	40		
30	40	50		
Pan	Pan	Pan		
Total				

REMARKS

Figure 5 - Post-Job Sieve Analysis