INCREMENTAL IMPROVEMENTS IN 50:50 POZ CEMENTING YIELDS ENHANCED PROPERTIES & COST-EFFECTIVE APPLICATION

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ABSTRACT

For nearly 50 years, admixtures of 50:50 Class H (or Class C): Pozzalon with 2% bentonite have functioned effectively worldwide as lightweight slurries for situations where heavier completion cements posed a risk of exceeding low fracture gradients in a particular wellbore. Pozzolanic materials are lightweight, and effectively combine with calcium hydroxide that is liberated during the hydration of portland cement. Historically, the 2% bentonite has been utilized to assist in the specification of relatively high water-to cement ratios, and therefore lighter slurry density, without the generation of excessive free water as the cement progresses though the setting process. Though the bentonite has fulfilled the role quite well, it has two disadvantages: first, its presence in typical cement slurries reduces the effectiveness of a given concentration of most commercially available fluid loss additives. Second, while the 2% (by weight of cement) volume may seem of no consequence, the shipping costs associated with moving tons of the material over a long period of time can be significant.

A project was undertaken to determine whether or not there were other commercially available materials that could substitute for bentonite and yield improved slurry qualities at the same or reduced cost.
Extensive testing of 50:50 slurries revealed that small quantities of sodium metasilicate (on the order of 0.5% by weight of cement) could effectively replace bentonite. Free water was controlled to the same degree, and a synergy with a commonly available fluid loss additive was discovered, allowing either a) less total fluid loss additive for a given fluid loss control tolerance, or, b) better fluid loss control for a given concentration of fluid loss additive.
The testing is summarized, and relative economics associated with the systems are discussed

INTRODUCTION

The use of bentonite as a retarder has been for years in the oil service industry. But in recent years it has become of great concern to look into better quality control, cost savings, superior slurry performance, improved handling and logistics that could improve operations.
In the industry today, the 50:50 Class H (or Class C): Pozzalon with 2% bentonite has been used for predominantly the control of excessive free water in cement systems. But also, there has been the problem of bentonite reducing the effectiveness of fluid loss additives and the clumsiness of having to transport this material to site has been a reason to look at better options or a substitute. However, cement ageing, additive shelf life, slow compressive strength development and end slurry sensitivity to density variation are some of the limitations associated with the use of slurries.

The ability to control free water has been a major concern in the industry especially with the Class H cement which has an inherent free water problem. But continuous improvement through tests has in recent times reduced the vulnerability of class h cement to free water. This project more than ever before, control free water in both class H and C, and also increase in the precision of fluid loss for given concentrations of additives. Increasing environmental concerns are causing the industry to look for ways of minimizing the environmental impact of their operations. Complete elimination of unused waste, as well as improved concentration tolerances of liquid additives systems through the development of new systems and closed-loop processes is making this a reality. This study provides basic cement slurry design data using a liquid-additive (sodium silicate) cement system for intermediate casing cementing operations. Cost comparison results of different surface casing cementing scenarios for both liquid-additive (sodium silicate) and 2% bentonite are also presented.

SLURRY DEVELOPMENT

Slurry development was governed by two main constraints; namely TRRC requirements and operational constraints.

TRRC Constraints

The TRRC constraints are critical for designing surface and intermediate casing cement slurries. They are imposed mainly to ensure that the casing is securely anchored in the hole in order to effectively control the well at all times, and that all usable-quality freshwater zones be isolated and sealed off to effectively prevent contamination or harm with other reservoir fluids in the well bore trajectory. In intermediate casing cementing operations, Rule 13.13 of the TRRC states that cementing should be done from the shoe to a point at least 600ft above the shoe. But if any productive horizon is open to the well bore above the casing shoe, the casing shall be cemented from the shoe up to a point at least 600 ft above the top of the shallowest productive horizon or to a point at least 200 ft above the shoe of the next shallower casing string that was set and cemented in the well. Cement slurries with volume extender may be used above the zone of critical cement to cement the casing from that point up to the ground surface. The TRRC cement quality requirements for cement slurries in these zones are shown in Table 1.

Operational Constraints

These are slurry design criteria imposed to optimize the cost and quality of the cement slurry in the field. Slurry viscosity, thickening time, fluid loss and free water are the three major operational constraints employed in this project.

I. **Slurry Viscosity**: This shows the ease with which slurry can be pumped down hole. Slurries that are difficult to mix can result in operational problems in the field. Previous studies have indicated that rheologies greater than 40 at 6 rpm and 30 at 3 rpm may indicate the potential for field mixing problems. Rheologies less than 5 at 6 rpm and 4 at 3 rpm may indicate solids separation and excessive free water. The sodium metasilicate concentration impacts slurry viscosity. Figure 2 shows the effect of sodium silicate on the rheology of the cement slurry.

II. **Thickening Time**: Slurry thickening time must correlate to actual planned pumping time, and must fall within reasonable industry standards. . It impacts both cost and cement quality. This study was able to correlate through the heat equation; reasonable temperature profiles of the two slurries with time using the consistometers, showing time required to thicken (this is shown in the appendix). Thickening times less than 2 hours are generally too short, and can significantly increase the risk of premature cement setting prior to proper placement; while thickening times greater that 6 hours are generally to long, leading to extended compressive strength development and/or formation fluid migration problems.

III. **Fluid Loss:** The rate at which slurry losses water at different pressures is important as this allows for proper selection of slurries at different pressure and depths. A high fluid loss would be inversely proportional to the thickening time, when fluid goes out of slurry quickly, it thickens faster, and a low fluid loss indicates a likely longer thickening time.

IV. **Free water**: This is both common to both the TRRC and operational constraints. Under the TRRC requirements, the API free water separation shall average no more than 6 ml/2hrs. However, due to the desire to prevent separation of cement and water in the well bore and provide a margin of safety, a constraint of 5 ml/2hr was imposed.

HISTORY OF DEVOLVEMENT AND RESULTS

The need for sulfate resistance and light weight slurries in the Permian and Mid-continent Basins has led to the dominant use of API Class C for shallow cementing operations, and was a major consideration in the selection of the cement class used in this project, though Class H was also tested for consistency and possibility of new use in shallow cementing operations.
Initial testing reveals that use of API Class H + fresh water yields unacceptable free water and thickening times. Figure 4 shows the relationship between free water and SMS concentrations.

But subsequent tests reflect a free water level under the tolerance point of 5.0ml/2hrs. The main challenge in determining better slurry than the Gel slurry was to determine the amount of SMS that will yield the same or better properties and optimum results in terms of total system cost and quality than the Gel slurry. This was done by trial and error, till the best concentration possible was determined. Fresh water was used along with 2% BWOW Nacl.

Consequently, for the class C cement has shown in figure 5, for different concentrations of the SMS, they were all below the tolerance value, but other tests carried out for thickening time, fluid loss, compressive strength and rheology shows 0.5% SMS having better values of this slurry properties than the Gel slurry.

TESTING EQUIPMENT

The testing equipment used meets API 10B 22nd Edition, Dec 1997, and includes:

1. Pressurized Consistometer Unit
2. Rotor-bob type Rheometers
3. Free water testing apparatus
4. Compressive strength testing equipment
5. Atmospheric Pressure Consistometer Torque indicator
6. Fluid loss filters Press.

A basic cement slurry design specification for intermediate cementing operations was developed using a SMS system. Table 2 shows the complete slurry design data.

CONCLUSIONS

The following conclusions were arrived at:

a. Economics of using SMS are relatively comparable to current use of Bentonite system for most jobs.
b. Economics of using SMS when cementing large casing down drill pipe can be highly favorable.
c. Basic slurry design data are presented.
d. Additive concentration tolerances are improved when SMS additives are used.
e. Less waste is possible when SMS are utilized, resulting in a more environmentally responsible process.

RECOMMENDATIONS FOR FURTHER INVESTIGATION

a. Examination of multiple fresh waters with various salts.
b. The use of sodium silicate as an extender in casing strings subsequent to the intermediate pipe. (Phase 3)
c. Closer examination of process control – (Phase 3)
d. Substitution of NaCl with $CaCl_2$

REFERENCES

1. Specification for Materials and Testing for Well Cements. API Specification 10 (Spec 10) Fourth Edition, August 1,1988
2. Casing, Cementing, Drilling, and Completion Requirements. TRRC Rule 13, August 13, 1991
3. Grant, W.H., Rutledge, J.R., and Christy, R.H. “Field Limitations of Liquid-Additive Cementing Systems” SPE 18616, 1989
4. Gerke, R.R., “A Study of Bulk Cement Handling and Testing Procedures” SPE 14196, Las Vegas, September 1985
5. Liquid Sodium Silicate Cement Research Project, Texas Tech University, December, 2002
6. Ogunsanya, S, Zhao, X, Heinze, L.R, and Walser, D.W. “Liquid Additives Control Cement Slurry Properties” SPE 2003.

Table 1
TRRC Specifications, Rule13

Extender Slurry		
Duration (Hours)	12	24
Compressive Strength (Psi)	100	250
Tail Slurry		
Duration (Hours)	12	72
Compressive Strength (Psi)	500	1200

API Free Water (ml/2hrs)	6

Table 2
Slurry Design Data Class C Cement

	50:50 2% Gel	**50:50: 0. 5% SMS**
Slurry Specification	API Class C,14.2ppg + 14.2ppg (SMS) + 2% NaCl	API Class C , 14.20ppg + 14.2ppg (SMS) + 2% NaCl
600rpm	102	110
300rpm	72	87
200rpm	59	74
100rpm	45	61
6rpm	19	37
3rpm	16	28
API Free Water	2.1ml/2hrs	2.0ml/2hr
Thickening Time (74Bc)	3hrs, 36mins	3hrs, 19mins
8hrs	N/A	N/A
12hrs	60psi	0psi
24hrs	750psi	1938psi
Fluid Loss	368 cc/30mins	I335 cc/30mins

Class H Cement

	50:50 2% Gel	**50:50: 0. 5% SMS**
Slurry Specification	API Class C,14.2ppg + 14.2ppg (SMS) + 2% NaCl	API Class C , 14.20ppg + 14.2ppg (SMS) + 2% NaCl
600rpm	51	96
300rpm	29	71
200rpm	22	55
100rpm	15	42
6rpm	4	15
3rpm	2	13
API Free Water	6.5ml/2hrs	2.5ml/2hr
Thickening Time (74Bc)	5hrs, 53mins	4hrs, 11mins
8hrs	N/A	N/A
12hrs	0psi	263psi
24hrs	737psi	921psi
Fluid Loss	1697.14 cc/30mins	1009.09 cc/30mins

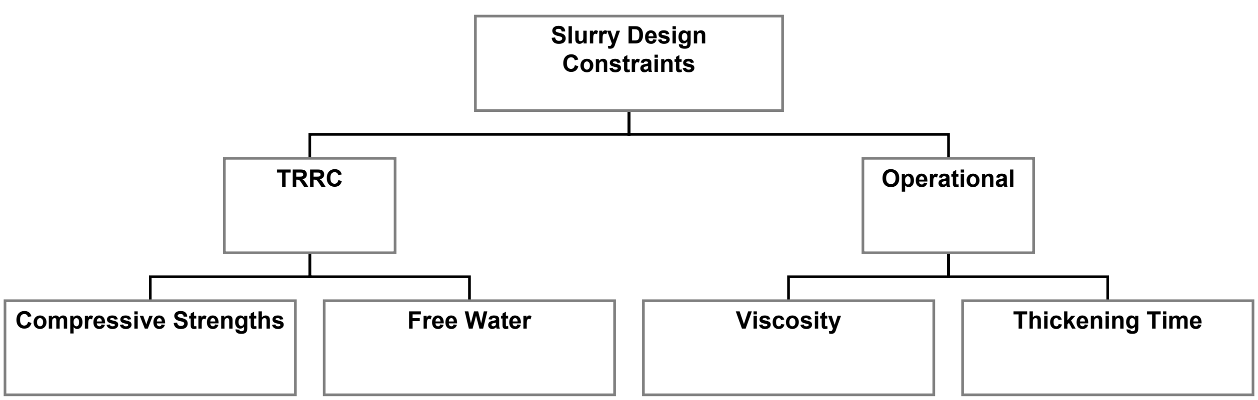


Figure 1 - Chart of Slurry Design Constraints

Figure 2 - Correlation between Slurry rheology and RPM

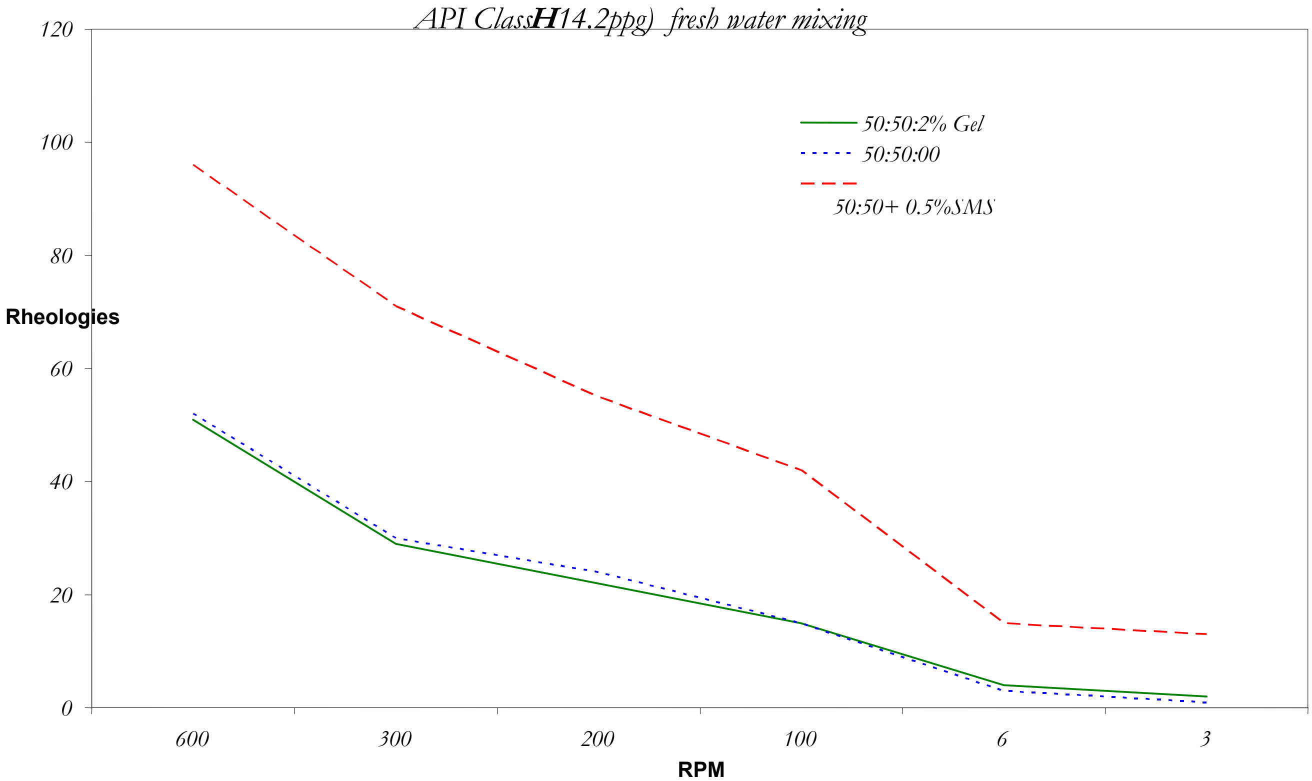
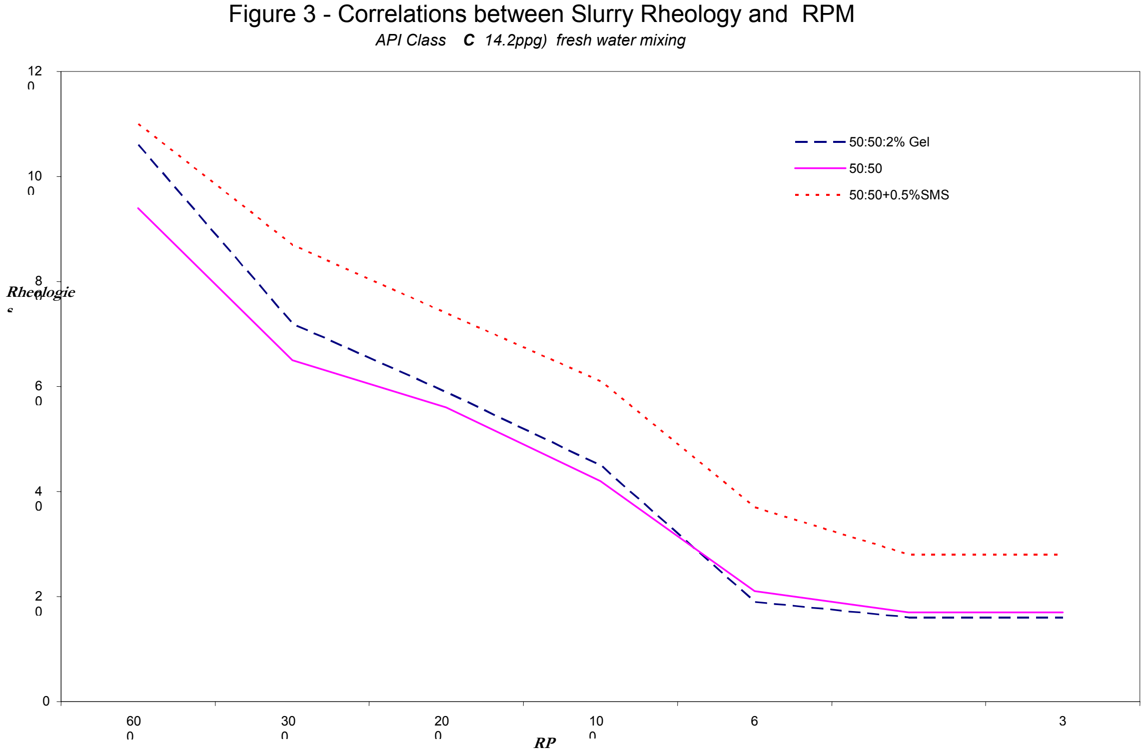


Figure 3 - Correlations between Slurry Rheology and RPM



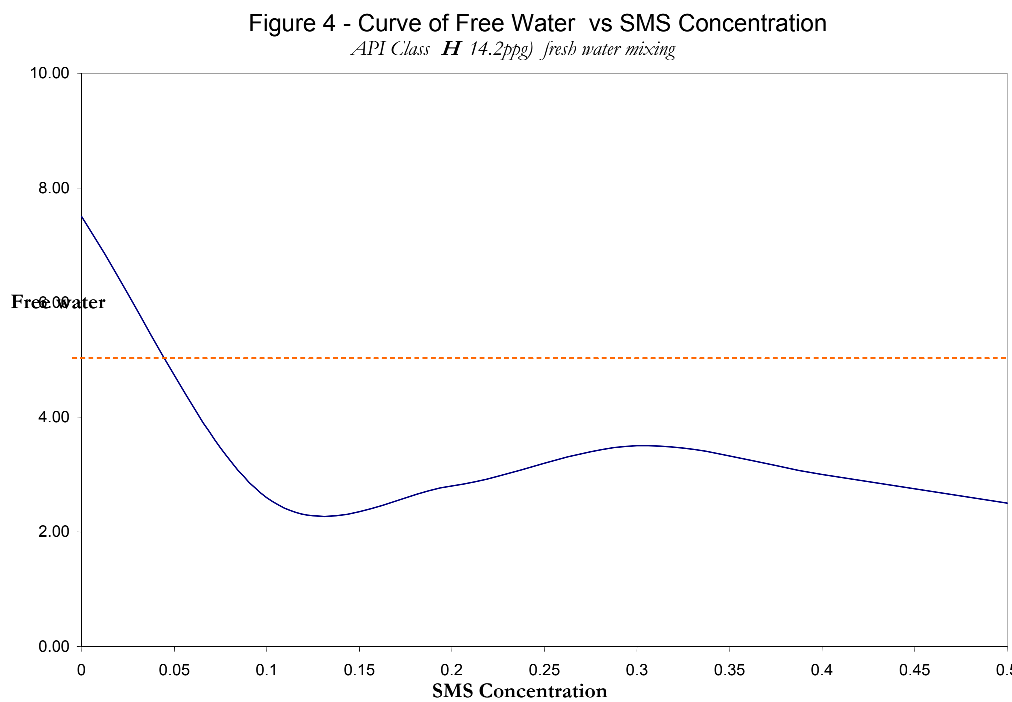


Figure 4 - Curve of Free Water vs SMS Concentration
API Class H 14.2ppg) fresh water mixing
10.00
8.00
6.00
Free Water
4.00
2.00
0.00
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5
SMS Concentration

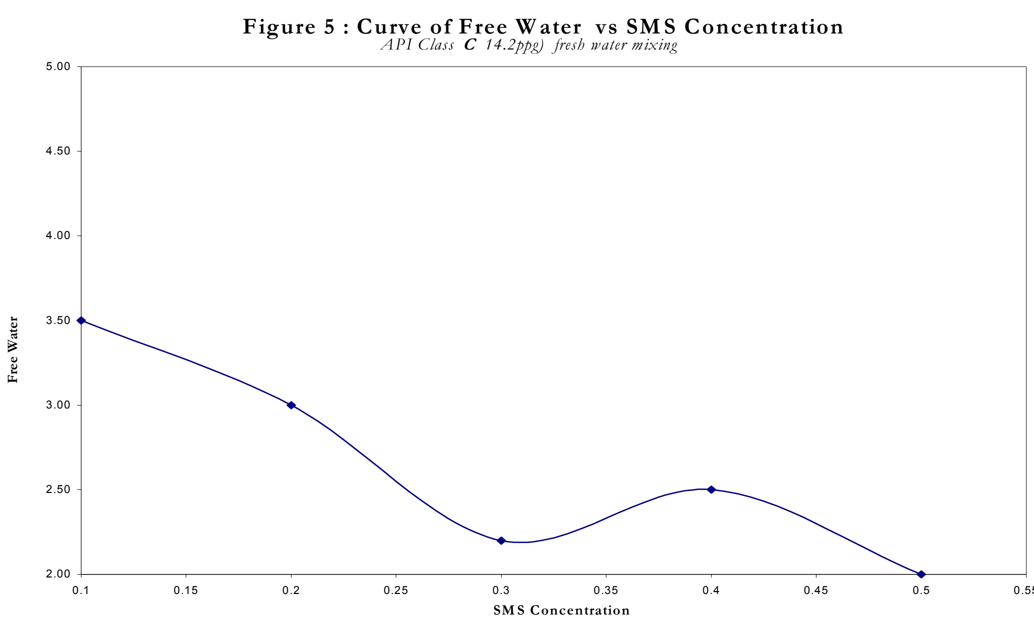


Figure 5 : Curve of Free Water vs SMS Concentration
API Class C 14.2ppg) fresh water mixing
5.00
4.50
4.00
3.50
3.00
2.50
2.00
Free Water
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5
0.55
SMS Concentration