# ENGINEERING AND OPERATIONAL CONSIDERATIONS WHEN USING RESIN COATED PROPPANTS

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## ABSTRACT

In the last two years, the oil and gas industry has seen an increase in the use of resin coated proppants in hydraulic fracturing treatments. Resin coated proppants are now used routinely in a wide range of reservoir conditions.

This paper will examine several key issues which should be considered when using resin coated proppants.

1. Operational procedures and problems encountered with resin coated proppants.

2. Treatment design parameters with resin coated proppants in low and moderate temperature reservoirs.

3. Fracturing fluid compatibility with resin coated proppants.

4. Laboratory and on-site quality assurance and quality control tests to ensure fracturing fluid compatibility and performance with resin coated proppants.

A standard method for testing proppant compatibility with fracturing fluid systems will be presented. Quality assurance and quality control procedures for proppant compatibility with fracturing fluid systems should include the above method.

## OPERATIONAL PROCEDURES AND PROBLEMS

The first concern when dealing with resin coated proppants is the actual delivery of the proppant to the job site. With very little inventory of specialty proppants kept in stock at most locations, service company operators or contract haulers will be utilized to deliver the proppant. Two possible problems may occur. One problem is dealing with the potential for contaminates if a contract hauler is used and a second problem is supervision of the proppant loading process. Manufacturers specifications dictate that the maximum blow down pressure for resin coated proppant is 5 PSI. Pressure in excess of 5 PSI will damage the proppant coating and create excess resin fines. Extra time and supervision should be used, especially when dealing with contract haulers to ensure the proppant is delivered to location according to the manufacturers specifications.

Proppant delivery problems encountered during the actual treatment can be categorized into three categories. The first category concerns the blender's ability to move resin coated proppant using common sand screw configurations. Calibration tables generated for blenders using uncoated proppants do not compare to data generated when using resin coated proppants. Initially, it requires 30 to 40% more RPM at the feed screws to get the system fully loaded. Apparently this is due to the blenders inability to move resin coated proppant in a linear fashion when compared to plain sand. Once the system is fully loaded it requires a much smaller RPM change to effect the desired changes in the treatment. Field data has shown an increase of 15 to 20% in actual slurry density when changing from uncoated proppant to resin coated proppant with no change in discharge rate or feed screw RPM. Dependent upon the proppant delivery rate and blender discharge rate at the time of this change over, significant operational problems can occur.

Field testing was performed in an effort to make the transition from uncoated proppant to resin coated proppant smoother. Other than the problems previously discussed, the data generated also suggested that there was a significant difference in the wettablility of uncoated proppant versus resin coated proppants. At high pump rates and proppant delivery rates, excessive air entrainment was noted causing poor blender performance and downhole pump cavitation. A water wetting surfactant and defoamer used on subsequent treatments during the resin coated stage kept the pumping equipment on line and running smoothly.

The second category of problems concerns the actual density measurement of resin coated proppants during the treatment. Some densiometers currently used allow for three specific proppant settings; sand, intermediate, bauxite. Current operations allow for the densiometer to be zeroed, calibrated to the specific gravity of the base fluid, and a single calibration for the proppant to be pumped. The majority of treatments pumped in the Permian Basin tail-in with a predetermined amount of resin coated proppant. When the change is made to resin coated proppant, the high and low pressure densiometers are still calibrated to uncoated proppant. Since there is not a predetermined set switch on the densiometer for resin coated proppant, the resin coated proppant is measured as plain sand. This practice will cause the resin coated sand stage to run heavy in the range of 3 to 10%. Dependent upon the stage size this can result in running out of proppant early, or in a worst case senario, slugging the formation and creating a screen out situation.

The third and final category of possible problems concerns the accurate addition of proppant curing activators during the treatment. Activators are generally added on the fly in concentrations ranging from 5 to 10 gallons/1,000 gallons of treatment fluid. Too little activator during a stage will result in poor proppant performance, too much activator may be detrimental to the performance of the fluid system.

## TREATMENT DESIGN PARAMETERS

The largest portion of treatment design considerations for the Permian Basin concerns low temperature, low pressure reservoir environments. In this environment proppant migration or fines migration into the well bore, are a common occurrence after a stimulation treatment. The most common proppant of choice for this reservoir condition is 4% curable resin coated sand, with some use of the 2% variety. The 2% and 4% denote the amount of resin on the sand grain by weight. An acceptable rule of thumb for designing a tail-in stage of resin coated sand is to place the resin coated material approximately 75 to 100 feet into the formation. Table 1 shows a simple calculation which can be used in conjunction with a 2D perfect proppant transport fracture model, to determine the accurate amount of resin coated proppant needed. Solving the equation in Figure 1 results in cubic feet of resin coated material required. Multiplying the result by 2 gives the total cubic feet of proppant required for both wings of the fracture. Cubic feet of proppant can then be multiplied by the bulk density of the proppant to determine total pounds required for the treatment.

Pumping procedures for the proppant activator and the breaker schedule for the treatment should receive special attention prior to the treatment. As mentioned previously, 5-10 gallons per 1,000 gallons of base fluid is the recommended activator loading depending upon the manufacturer. It is recommended that the entire resin stage contain the proper activator loading.

Breaker schedules should be designed and tested to allow the fracturing fluid to break prior to the curing of the proppant pack. This ensures that good point to point adhesion will occur in the pack. Using a technique such as Forced Closure can also achieve the same effect as an accelerated breaker schedule. Finally, accurate flush and displacement calculations are necessary to prevent excessive proppant settling and curing in the well bore, keeping the operators clean-out costs to a minimum.

## FLUID COMPATIBILITY TESTING

In an effort to verify fluid compatibility with resin coated proppants, several fluid systems commonly pumped in the Permian Basin were tested. Various concentrations of 2 and 4% curable resin coated proppant were used and compared to identical proppant loadings of 20/40 Brady Sand. Both sets of crosslinked proppant samples also were compared to blank samples with no proppant. Observations were made of all fluid samples concerning crosslink time, crosslink appearance, proppant dispersement or lumping, and proppant settling. Table 2 shows the fluid systems that were tested along with base gel parameters of viscosity , temperature, and pH. Table 3 is a table of proppant concentrations and activator loadings that were tested with each fluid.

The borate systems tested showed no signs of incompatibility throughout the testing. The most significant observation was made with the transition metal crosslink system, utilizing two common metal crosslinkers for the test. A normal crosslinker loading of 1.2 gal/1,000 proved acceptable when testing the blank samples or the plain Brady Sand samples. The crosslink time and appearance with the 2 and 4% resin coated proppant required twice the crosslinker loading to achieve the same results as the blank and plain Brady Sand sample. Six hour breaker schedules at 100 F were also run on each of the fluid systems with some anomalies noted but no conclusive data at the present time. It is generally accepted that the proppant curing activator, an alcohol, can have an extending effect on the gel break time. Testing is still being performed to evaluate the activator effect at low and moderate temperatures.

## LABORATORY AND FIELD QC/QA TESTING

Information generated from the compatibility testing, along with suggestions from field personnel has lead to several practical and simple quality control and quality assurance procedures.

### At The Well Site

1. Close supervision should be made if a service company is required to use contract haulers for proppant delivery. Insure that the proppant ordered is exactly what is delivered. Also, verify that the proppant is blown off to manufacturers specifications.

2. Make a close inspection of the bulk equipment being used and the proppant that is being off loaded to ensure it is free from contamination.

3. Ensure that the transports are completely blown down and collect weight tickets for each load delivered. If there is a visual discrepancy in the amount delivered, have the trucks reweighed empty to verify totals. After all the proppant has been delivered to location, samples from each compartment of the Sand Master should be taken and marked.

4. A very simple and effective way to test the proppant for contamination that may not be visible is as follows: Using DI water with a pH of 7, put a quantity of proppant from one of the samples taken into the DI water and shake well. Again test the pH of the water now containing the proppant sample. If a notable change has occurred in the pH, you should have reason to believe the proppant sample is contaminated. Repeat for each sample taken.

5. If the development of a breaker schedule is required, ensure that the job chemicals, frac tank water, and proppant samples are delivered to the service company's district or region lab for

testing. In the case where resin coated proppant is being used, a more detailed breaker test is required.

6. Gel the required amount of fluid for the breaker tests with the chemicals and water supplied by the field. Determine the maximum resin coated sand concentration to be pumped during the job and weigh-out a representative sample. For a 300 ml breaker test this would be calculated as follows:

$$PSA \times 36 = \text{gms sand added}$$

Place the fluid in a blender jar and mix while adding the proppant sample that was weighed out for the test. After dispersement of the proppant in the fluid, add the required amount of proppant activator and disperse. Add the required amount of crosslinker for the gel to complex. Place this sample along with a blank sample in a water bath for the required break time. Note any discrepancies in the break times between the two samples and adjust the breaker loading as necessary for a uniform break.

## CONCLUSION

Considerable research is continuing with resin coated proppant manufacturers in the refinement and continued development of their products. One manufacturer alone offers seven different resin coated product types. Each is designed for use in varying reservoir conditions. With this in mind it is important that service company's continue to monitor and test these different products with current equipment and fluid systems. One reason for this testing is obviously product compatibility, but just as important, testing should be performed with equipment, to ensure operational compatibility. Considerable thought should be given to the design of equipment and how proppant, whether uncoated or coated in nature are moved on location. Some systems currently used in the field do not adjust adequately for varying proppant types and delivery schedules.

Considerable responsibility is put on service company engineers and service supervisors to ensure that the treatment fluids are mixed properly on location. With the exception of transition metal crosslink system, no apparent problems with compatibility were noticed when testing with resin coated materials. The key here is that the fluids were mixed precisely in a laboratory environment, where as a border line fluid mixed in the field may reveal severe problems with resin coated materials. The simple Quality Control procedures outlined in this paper should help eliminate any guess work in the field and allow the service supervisor to perform the treatment the way it was designed.

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