Survey of Best Practices for Paraffin and Asphaltene Control- A Preliminary Report

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Introduction

The results presented here are the conclusions reached by surveying key people within our industry on paraffin control. The survey was developed within the Permian Basin Operators Work Group that consists of members from Arco, Exxon, Pennzoil, Artificial Lift Solutions, Oxy, Cross Timbers, Burlington Resources, Amerada Hess, Texaco, Pioneer, Phillips and Chevron.

The group received forty-three completed surveys from the following twelve companies:

Amerada Hess	Phillips
Spirit Energy 76	Marathon
Pennzoil	Arco Permian
Oxy	Altura
Burlington Resources	Texaco E & P
Exxon	Chevron

Twenty-three counties in three states (Texaco, New Mexico and North Dakota) are represented in these data.

The survey asked each participant to rank his or her overall paraffin control program. The distribution of the self-rated effectiveness turned out as follows:

Poor	14.0%
Fair	32.6%
Good	48.8%
Excellent	4.6%

We have opted to break the discussion down by the programs' effectiveness ratings.

Poor Program Effectiveness

None of the programs having "poor" effectiveness reported testing their crude oil as a part of establishing their program. Testing to determine the API gravity, cloud point, wax melting point, paraffin and/or asphaltene content and carbon chain composition or make-up is extremely critical for a well designed control strategy. From the results of this testing, a program can be tailored to satisfy the specific needs of a given asset.

If the temperature of the oil falls below the cloud point, wax crystals will precipitate from the oil phase. Accumulation of these precipitated solids can impact surface and subsurface equipment operations. Paraffin precipitation is usually associated with changes in physical conditions surrounding the crude – primarily temperature or pressure. As it is produced up the wellbore, the crude temperature may drop due to the normal subsurface thermal gradient. Sudden pressure drops (such as taken through perforations, across chokes, etc.) also have a cooling effect on liquids and can promote precipitation. The reduction in hydrostatic pressure on crude as it is produced up the tubing will also allow gas to break out of solution. The gas bubbles that form as pressure is lowered are the "light ends" that were in the liquid phase helping to keep the "heavy end" paraffins in solution. This loss of the "light ends" from the liquid phase can also cause precipitation. The cloud point is dependent on the oil composition and is significantly affected by small amounts of high molecular weight paraffin in the crude. Asphaltene deposition, however, is not so much physically driven by temperature and pressure as it is by chemical changes in the crude system. The asphaltene molecules are not dissolved in the crude, but are dispersed, or "floating" in the oil. Lowering the pH of the system (making it more acidic) or introducing CO_2 or non-aromatic solvents can strip away the outer part of the asphaltene molecules that helps to keep them dispersed and will cause them to flocculate and precipitate. It is critical to gain an understanding of the characteristics of the crude oil prior to designing and implementing an effective control program.

The majority of the "poor" programs did not incorporate a scheduled treating frequency. If a schedule was followed, the time intervals between treatments seemed excessive. Due to the fact that hot oiling and hot watering jobs are so commonplace in the industry, it is sometimes taken for granted the work is being performed as instructed in a desirable, effective manner. However, continued ineffective or undesirable results can indicate poor performance in planning or execution of the jobs.

The fluid used was either lease crude or produced water. Regardless of the fluid, chemical was added to assist the process. However, the compatibility of the produced fluid, heated fluid, and chemical was not checked. Subsequently, on two occasions emulsions were noted in produced fluids following treatments. Several of the crude oils could be sensitive to specific compounds that could create emulsions or the produced water could be high in Total Dissolved Solids. Compatibility testing may allow you to head off these problems.

The volume of heated fluid typically pumped into the well bore equated to 70 bbls. Fluids were heated to between 150° F and 200° F and pumped at 1 bbl. of fluid per minute (bfpm). During the normal hot oiling or hot watering process, heated fluid is pumped into the annulus faster (+/- 70 bbls @ 1bfpm or 1440 bf/day) than the beam pump system can produce it. It is this phenomenon that leads us to believe large amounts of fluid may be lost to the formation – especially in low bottomhole pressure, higher permeability wells. As this fluid begins to cool it can accelerate plugging of the reservoir. Plugging agents often found in this fluid may include iron sulfide, iron oxide, clay, scale and paraffin or asphaltene. If lease crude is the fluid chosen for treatment, one could possibly reduce the potential detrimental effects by:

1.) Using the cleanest oil possible with the least amount of BS&W content.
2.) Using top oil and not bottom oil. Bottom oil is generally laden with higher BS&W contents.
3.) Adding chemical to assist in holding the paraffin particles in solution.

These programs also used a supplemental chemical treating program using either an aromatic or proprietary blend of chemical introduced into the well bore. These supplemental programs were noted as one of the best practices for the "poor" programs. Finally, these programs are not employing scrapers, guides, or coatings for paraffin control.

Fair Program Effectiveness

Deposition on the "fair" programs centered around 3,000' or less with the majority focused in the surface to 2,000' interval.

Again, the opportunity for testing the crude oil appears as a potential method for improving effectiveness. Across the industry, regardless of program effectiveness ranking, this appears as an opportunity for improvement.

The "fair" programs were generally on a scheduled treating program. This schedule varied from 30 to 90 days, dependent upon the specific needs of each area. The majority of these treating programs used either lease crude or produced water, which contained a chemical additive. The largest success factor appeared centered around not only on using chemical additives, but also checking the heated fluid, produced fluid, and the chemical for compatibility.

The volume of heated fluid per treatment was overwhelmingly 70 bbls pumped at rate of +/- 2 bfpm and heated to between 150° F and 200° F. The improvement in effectiveness of the "fair" programs over the "poor" programs may well be due to generally increasing the pump-in rate from 1 bfpm to 2 bfpm. This is consistent with predictive work done by Sandia National Labs in Albuquerque, NM. A.J. "Chip" Mansure, Sandia Labs, developed a computer program to predict fluid temperature downhole in both the tubing and the tubing-casing annulus during hot oiling or hot watering jobs. Some results from the predictive runs are plotted in Figure 1. These data show that the same downhole temperature can be achieved at almost twice the depth by increasing the pump-in rate from 1 bfpm to 2 bfpm. Similarly, Figure 2 illustrates the positive effect of increasing the initial pump-in temperature of the fluid being used. These data are also results from the Sandia program.

The hot oil and hot watering treatments were supplemented with various chemical programs using condensate, aromatics or proprietary blends. Possibly these treatments are prolonging the time between hot oiling and hot watering treatments.

Rod guides or scrapers were not used on a wide scale. In some cases these devices are being evaluated by different operators. In these evaluations they were run from surface to 4,500' in various configurations. No one in this group reported using coatings for paraffin control.

"Fair" programs noted their effectiveness was developed through trial and error refinement. Furthermore, comments indicate a clear opportunity and desire to more efficiently control asphaltene deposition. Also it was noted that more science needs to be applied to hot oil / hot water programs to enhance problem solving efforts. This upfront planning could reduce operating expense thus increasing the profitability of the operation.

Good Program Effectiveness

It appeared from the surveys that these programs employed more upfront testing and planning. Almost 49% of the surveys shared programs with good effectiveness. However, there still appeared to be an opportunity to test the crude oil prior to implementing a paraffin control program.

Deposition ranged from surface to 3,000' with the majority of the deposition noted from 2,001' to 3,000'.

In this category there is an adherence to definite scheduled programs. These schedules have the bulk of the treatments occurring between 30 and 60 days. These programs used lease crude that was enhanced by the addition of chemical. The compatibility of the produced fluid, heated fluid, and chemical was verified. This chemically enhanced fluid, totaling 70 bbls, was heated to a temperature ranging from 150° F to 200°F and pumped at a rate of +/- 2 bfpm.

Some "good" programs also included a chemical treating program, but not on a widespread basis. Only 52% of these programs supplemented the hot oiling with aromatics or a proprietary blend.

Widespread use of scrapers or guides was not reported. Those in use are strictly in a test environment. These tools were placed in various configurations ranging from the surface to the seating nipple, from the seating nipple to 1,000' above it, and from the surface down to 3,000'. There did not appear to be an exact science for the deployment of these devices.

These successful programs were developed through trial and error. Many shared that without a planned scientific approach, "the human factor" becomes a large contributor to the success of any program.

Excellent Program Effectiveness

It was noteworthy that only 4.6% of the completed surveys rated their paraffin control programs as excellent.

The "excellent" programs tested the heated fluid, produced fluid, and the chemical for compatibility. The range of paraffin deposition was from the surface to 2,000', while a rigid treating schedule was employed. This hot oiling / hot watering programs treated the wells monthly.

The fluid used in these treatments was either lease crude or produced water. In either case chemical was added to the heated fluid in which the compatibility had been checked. Each treatment involved 70 bbls pumped at 1 bfpm heated to 150° F to 200° F.

These "excellent" programs were not supplemented with additional treating programs and neither scrapers, guides nor coatings were used.

Conclusions and Recommendations

Based on the responses received in this survey, it appears that there is not a large degree of upfront planning or testing performed prior to initiating paraffin control programs. More upfront planning could reduce the cost associated with learning and refining programs by trial and error and thus enhance profitability. This upfront planning should consist of:

⇒ Testing the crude for API gravity, cloud point, wax melting point, paraffin / asphaltene content, and carbon chain composition.

⇒ Assuring compatibilities of the heated fluid, the produced fluid, and any chemical solvent / dispersant used. Emulsions were noted in the programs where the compatabilities were not checked. Adding a solvent / dispersant assists in holding the melted particles in solution

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The most prominent pump-in volume was 70 bbls while the rate was 1 to 2 bfpm.
While pumping heated fluids (crude or water) the following should be considered:

⇒ Heat fluids to as high an initial temperature as safely possible without exceeding the short-term temperature exposure rating for any limiting equipment (e.g. fiberglass rods, fiberglass or polyethylene tubing or flowlines, etc.).

⇒ Pump fluids as fast as possible with exceeding limits of production facilities.

The data showed it is difficult to obtain an acceptable paraffin control program without a chemical inhibition program.

Currently there does not appear to be widespread industry use of rod guides, scrapers, or coatings for paraffin control.

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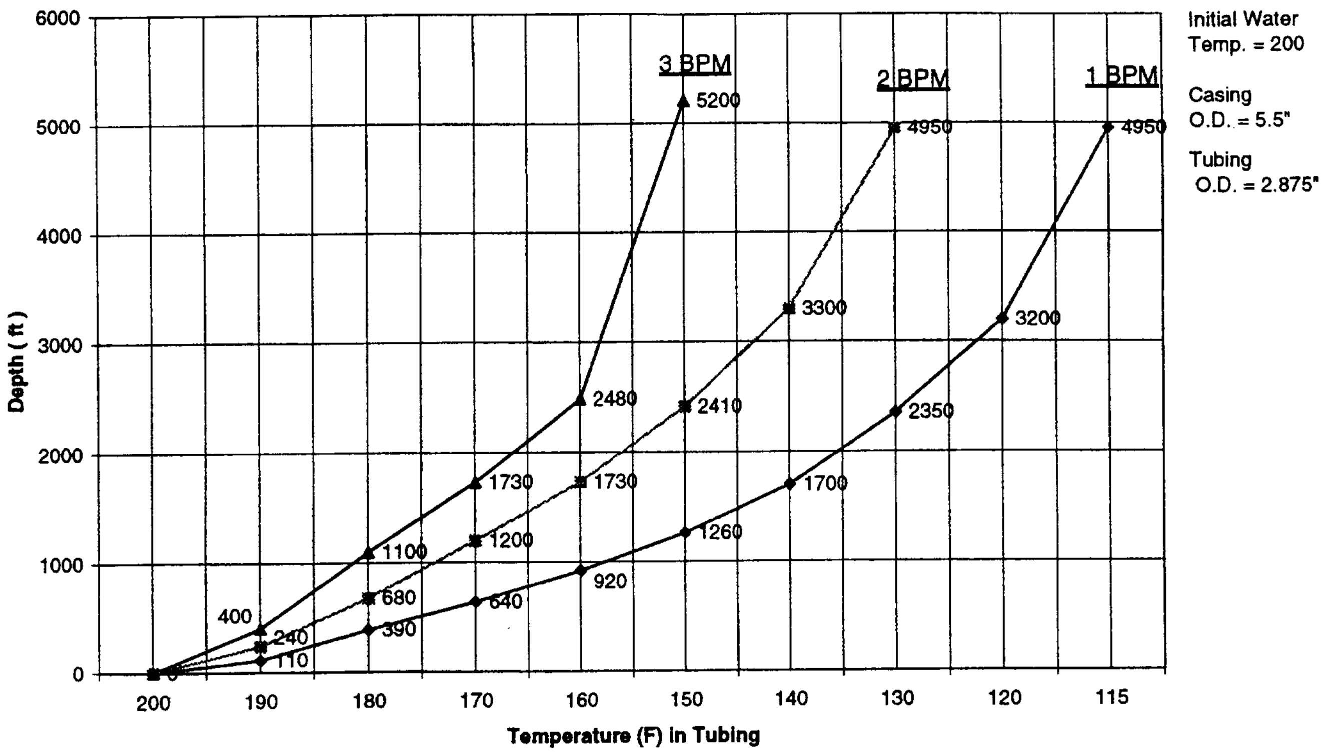

Figure 1 - Comparison of Hot Watering Pump Rates on Effective Depth

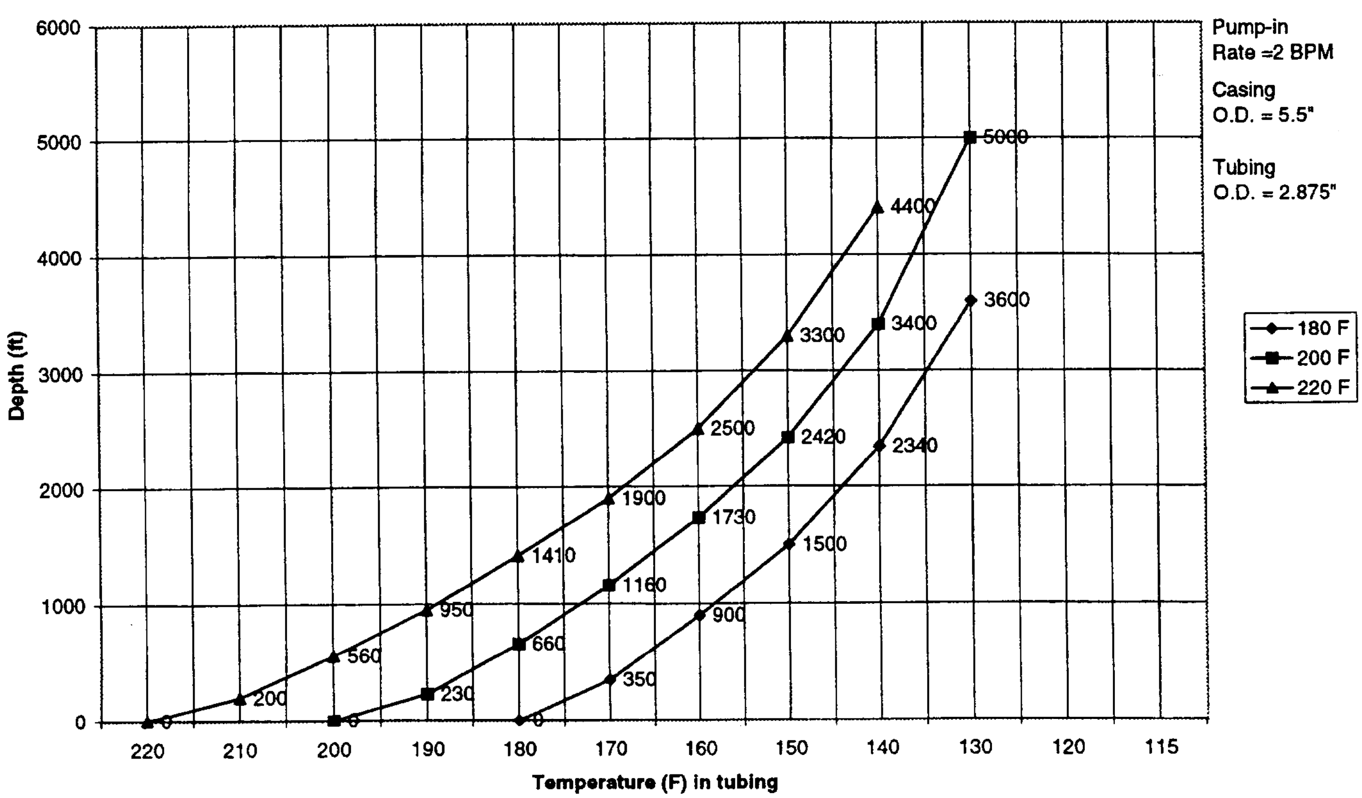

Figure 2 - Comparison of Hot Watering Initial Temperatures on Effective Depth