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Onsite Disposal of Rig-Generated Waste Via Slurrification and Annular Injection

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ABSTRACT

The technique of using on-site injection of oil base cuttings into a casing annulus is widely accepted as an environmentally attractive, cost-effective disposal alternative. A joint research project was undertaken by Conoco with a cuttings injection service company, Apollo Services, to pursue technological enhancements to the original technique. The result of the research initiative was development of a means to incorporate other non-hazardous wastes into the cuttings slurry. The slurrification and the disposal by injection of a wide variety of waste products is now potentially possible. The cuttings/waste injection process, nicknamed 'CUTWIP", provides both a systematic design assessment for implementation and a mechanical means of accomplishing this task. Process utilization eliminates repeated handling and transport of waste products from the drilling rig to land disposal sites. The risk of accidentally discharging either solid or liquid waste into the Gulf of Mexico waters or any other environmentally sensitive area can now be minimized.

This paper addresses development of the CUTWIP process, equipment and operational requirements, well design, permitting, and project economics. Results of the initial field application undertaken while drilling the East Cameron 56 JB-3 well in the Gulf of Mexico are also reviewed.

INTRODUCTION

Environmental issues are headline news for the 1990's. Everyone is fully aware of the impact of the large volumes of waste products generated in every phase of our business and personal lives.

References and figures at end of paper.

Landfills are closing; the handling of non-hazardous as well as hazardous waste materials captures everyone's full attention. Suitable alternatives for waste disposal having minimal impact on the environment are actively sought. The costs of such efforts are often secondary to environmental concerns. Recycling and waste minimization efforts abound. Cleaning our environment is today's and tomorrow's directive.

Within the drilling operations environment, approximately 250 tons per month of assorted non-hazardous wastes are routinely generated by a single mid-size oil and gas producer operating within the Gulf of Mexico area. Multiplied by the large number of operators drilling and producing within this sector, the waste products which will ultimately require disposal at land sites becomes staggering.

Oil base mud is frequently used for drilling the more difficult exploratory and development wells, and as such generates large volumes of oil base coated formation cuttings. These cuttings normally require transport to land facilities for disposal, further contributing to an already massive environmental problem. The slurrification and injection of oil base cuttings into a casing annulus, a process developed in 1989 by a major oil and gas producer/operator, has proven to be a significant step toward reduction of such environmental waste. Additional research has been directed toward incorporation of other non-hazardous wastes, such as mud/chemical sacks, shrink wraps, plastic containers, cans, galley waste, cardboard boxes, and wood, into the cuttings slurry.

This paper is comprised of five sections. Well Planning provides details of the basic well plan used to attain exploratory objectives, and also addresses specific injection design criteria. Equipment and Operational Requirements identifies the mechanical means for process implementation. Field Results provides an overview of injection results from the East Cameron 56 JB-3 well. Cost Analysis shares perspective on bottom-line economics. Conclusions summarizes overall findings, and provides technical recommendations as a framework for future research efforts.

WELL PLANNING

Drilling Program

The East Cameron 56 Block is located in the Gulf of Mexico approximately 40 miles offshore from the Louisiana coast. *See Figure 1: Location Plat.* The East Cameron 56 JB-3 well was planned as a development well from an existing platform. Proposed drilling operations were as follows: Drive pipe would be set at 200' below the mud line; 13-1 /2" hole would be drilled to 500'. The well would be kicked off to 26° inclination, and drilled to su rface casing point. See *Figure 2: Directional Plan.* Surface pipe (10-3/4") would be set at 4985'MD/4650TVD. After conducting a leak off test, 97/8" intermediate hole would be drilled to 11157'MD/10200'TVD. This hole section was comprised of massive sand and shale sections with no hydrocarbons expected within this interval. Next, 7-5/8" casing would be set, with the top of cement at +/7500'MD/6909'TVD. Water base mud would be used from spud to intermediate casing point. Oil base mud was proposed for drilling the final interval from 11157'MD/10200'TVD to 12826'MD/11700'TVD. Provisions for oil base cuttings injection and field testing of CUTWIP were to be afforded if mechanically possible. The 10-3/4" x 7-5/8" annular interval from 4650' to 6909' TVD would be available for CUTWIP implementation.

Proximity Considerations

Other wells on the platform, the JB-1 and JB-2, were temporarily plugged and abandoned. *Figure 1: Location Plat* also identifies the relative well positions. Based on an assessment of proximity considerations *(Figure 3: Proximity Comparison; Figure 4: EC 57 JB1 Wellbore Schematic; Figure 5: EC 56 JB-2 Wellbore Schematic/,* there was adequate horizontal displacement at the proposed injection interval to conclude that communications between the JB-3 and adjacent well bores should not occur.

Area Faulting

Figure 6: Seismic Cross Section. Figure 7: Objective Horizon, and Figure 8: Log Section illustrate the correlation between the surface and intermediate casing strings at the proposed annular injection interval . No major faulting existed within the proposed injection interval which could broach to the mudline and transmit oil base cuttings slurry or solid waste into the environment.

Fracture Analysis

Formation strength analysis for the East Cameron 57 area was undertaken to assist in planning the cuttings injection effort. The in-field EC 57 #4 S/T was used as the model well. This well offered the most complete data base of information available in the region. Fracture analysis entailed digitizing of existing logs and integrating all available drilling and mud logging information within the area. Elastic moduli and stress parameters were defined such that injection points were specified along with injection pressures. *Figure 9: Fracture Design Chart* was prepared from the integrated data. Estimated fracture pressures in the East Cameron 56 JB-3 well could be determined from the fracture design chart by correlating formation pressures, depths, and lithologies.

Pore Pressure. Mud Weight. and Fracture Gradients

The projected pore pressure, mud weight, and fracture gradient curves for the JB-3 are shown in *Figure 10. Pore Pressure, Mud Weight. Fracture Gradient versus Depth.* The pore pressure within the proposed injection interval ranged from 9.2 to 9.4 ppg. For slurry densities of 10.5 to 12.0 ppg, adequate hydrostatic pressure would be maintained throughout all injection operations. Annular cuttings injection would not compromise basic well control.

Casing Design

The calculated fracture gradient at the 10-3/4" surface casing shoe was 14.1 ppg. The calculated surface pressure required for fracture initiation was 870 psi. with a 10.5 ppg slurry density. The burst rating for the 10-3/4" 45.5# K-55 surface casing is 3580 psi. The collapse rating for the 7-5/8" 33.7# S-95 intermediate casing is 8800 psi. Assuming a 9.0 ppg back-up gradient for 10-3/4" burst design, and zero "gas" gradient for 7-5/8" collapse, a maximum surface injection pressure of 2680 psi was established. This would afford 1.2 burst and 3.28 collapse safety design factors. The proposed casing design would provide sufficient safety margin for injection purposes. Potential erosion of the 7-5/8" intermediate casing at the wellhead due to slurry injection would be eliminated by use of extended casing slips.

Cuttings Volume

Drilling of the 6-1 /2" hole section was projected to require 14 days. *See Figure 11: Planned Days versus Depth Drilling Performance.* Approximately 130 barrels of oil base cuttings would be generated by drilling the 1669' hole section (1.9 times gauge hole volume). Mixing 10 barrels of cuttings with 30 barrels of drill water would generate one 'batch" of slurry. It was projected that thirteen forty-barrel batches of slurry would be prepared for injection into the 10-3/4" x 7-5/8" casing annulus.

Waste Volumes

Generation of an additional 140 barrels (18 tons) of non-hazardous rig waste was also projected. All rig waste would be processed through a mechanical shredder mounted above the cuttings slurrification equipment. The material would be added to the oil base cuttings slurry for down-hole injection. The non-hazardous waste would include mud containers, paper, pallets, glass, plastics, visquine shrink wraps, metal buckets, paint cans, waste oil, rope, boards, and Styrofoam. The waste products would be added into the cuttings slurry at approximately 5 pounds per barrel, depending on the material's impact on slurry rheology. Only oil base cuttings, related waste wash water, and solid waste from the JB-3 operation were proposed for annular injection.

Permitting

Responsibility for permit approval for the East Cameron 56 JB-3 cuttings/waste injection effort resided within the jurisdiction of the Minerals Management Service IMMS), United States Department of the Interior -Lafayette District Office. Due to the proposed incorporation of other non-hazardous waste products, process approval by the MMS Regional Office was also required. Specific guidance was provided by the regulatory agencies. Items required within the application were as follows:

1. Origin of cuttings: well, footage drilled with oil base mud.
2. Calculated volume of cuttings to be injected (not slurry volume).
3. Slurry procedure, including volume of cuttings per volume of carrier fluid.
4. Slurry weight (ppg).
5. Maximum volume of cuttings to be maintained on board rig at any time.
6. Description of surface equipment involved (process flow schematic).
7. Calculated fracture gradients at shoe of annulus.
8. Maximum surface injection pressure.
9. Offset log showing proposed injection interval.
10. Geologic discussion of injection interval, presence of shallow hydrocarbon zones, faulting within the area that could transmit injection fluids back to surface.
11. Disposal must be deeper than 3000'.
12. Displacement fluids must be adequate for pore pressure environment.
13. Special provisions required to negate erosional effects upon casing at surface injection point.
14. Permanent identification of the well with regard to use of cuttings/waste injection.

Data Acquisition

A critical element of the field test was to ensure that good data and adequate samples would be acquired for future analysis. Utilization of a senior research technologist with supervisory assistance from a senior staff fluids specialist was solicited to provide guidance in determining what was required for proper process identification, and what was the best method to accomplish the objectives.

Throughout the field implementation of the CUTWIP process, samples of all slurry and shredded waste products were to be obtained and properly labeled. Noteworthy comments were to be prepared for later review. Once field samples had been obtained, thorough lab analysis would then be undertaken.

Radioactive Tracer Requirements

In order to properly assess the effects of the cuttings and waste products upon the injection points, provisions for radioactive tracer injection services were to be afforded. Three separate radioactive tracers, antimony, iridium, and scandium, were selected because of their low half-life, low material requirements, and safety considerations. These were to be used to determine the initial, intermediate, and final injection points. During the introduction of cuttings slurry or any solids laden fluid into the pump suction, radioactive tracer would be simultaneously injected to provide future confirmation of the projected injection point.

Antimony would be injected at the beginning of the injection process to establish the location of the initial injection zone, and would continue for the first one-third of the open hole interval. At approximately 11575', radioactive iridium tracer would be injected. At approximately 12200', radioactive scandium tracer would be injected until total depth had been obtained. Upon completion of all drilling operations, a multiple isotope tracer log would be run to determine actual injection points and also identify subsequent changes in injection point as a function of slurry composition and volumes injected.

Equipment and Operational Requirements

Figure 12: Mechanical Flow Schematic illustrates the basic system proposed for cuttings slurrification and waste shredding. Equipment consists of an augured conveyor system to move drill cuttings from the shaker area to the first of two blenders. Once cuttings reach the first blender, they are mixed at a ratio of one part cuttings to three parts water. The combined water and cuttings are processed through tungsten carbide centrifugal pumps where solids are mechanically dispersed into smaller particles. The mechanical shredder is located above the second blender. This unit is used to process assorted waste products into the cuttings slurry. Products processed through the shredder fall directly into the cuttings slurry below. Processed slurry is transferred from the blenders to a triplex pump for injection into the selected casing annulus.

EAST CAMERON 56 JB-3 FIELD RESULTS

Summary

Field testing of the cuttings/waste injection process (CUTWIP) was initiated during December 1991. Equipment and personnel for cuttings slurrification, waste shredding, injection, radioactive tracers, and logging services were provided per Conoco's direction. Objectives of the test were two-fold: first, while drilling the production hole section, dispose of all oil base drill cuttings generated, by using slurrification and annular injection; secondly, evaluate the feasibility of disposing of additional solid waste generated by drilling operations by mechanically shredding and incorporating the material into the oil base cuttings slurry prior to annular injection. This represented Conoco's first effort at either conventional cuttings slurrification or field testing of the CUTWIP process. Both objectives were successfully completed.

Drilling Operations

The rig was mobilized to location during mid-November, 1991. Drive pipe (24" X 5/8" WT) was driven to 380', 237' below mud line. Surface hole (13-1/2") was drilled to 500'. The well was kicked off, building inclination to 26°, and maintaining angle to casing point at 4990'MD/4650'TVD. Upon obtaining a 14.1 ppg leak off test, 9-7/8" hole was drilled to 10946'MD/10015'TVD. See *Figure 13: Well Bore Schematic.* No hydrocarbons were expected within this interval. However, productive hydrocarbons were present at 7600'MD/7010'TVD as evident in *Figure 14: Log Section.* Modifications in the cement program for the intermediate casing were mandated to provide a minimum of 500' of cement above the known hydrocarbon zones. This resulted in a significant reduction in the amount of open hole annulus potentially available for cuttings injection and increased uncertainty of injectability. After the 7-5/8" casing had been cemented, a temperature log was run. The top of cement was identified at 5700'MD.

Infection Rates and Pressures

Once cementing of the 7-5/8" casing had been completed and the casing slips had been installed, an immediate priority was to establish injection into the open hole annular section. Using the cementing unit, 1237 barrels of 11.3 ppg polymer mud were disposed of via annular injection into subsurface formations. See *Figure 15: East Cameron 56 JB-3 Initial Injection Rates versus Pressures.* Injection rates/pressures were as follows: 1 BPM @ 800 psi; 2 BPM @ 950 psi; 3 BPM @ 1250 psi; 4 BPM @ 1330 psi; 5 BPM @ 1550 psi; and 6 BPM @ 1800 psi. Surface injection pressures were as predicted by the fracture design chart.

With injection initiated, various formulations of cuttings slurry and waste products were prepared and were successfully injected. *Figure 16: Injection Rates/Pressures versus Cumulative Volume* depicts injection results. Cuttings and waste slurry were injected into the formation at rates from 1-3 BPM at pressures ranging from 1550-2090 psi maximum. Once waste slurrification had been discontinued and conventional cuttings slurrification and injection were undertaken, rates of 1 BPM at 1250 psi were the norm. Pressure gauges were installed for monitoring the JB-1 and JB-2 well annuli prior to the commencement of injection efforts. No changes in pressure occurred on the wells as a result of injection operations on the JB-3 well. Communications between wellbores was never evident.

Cuttings and Infection Volumes

The original well plan required drilling 1669' of 6-1 /2' hole from 11157' to 12826'. It was originally projected that 130 barrels of oil base cuttings would be generated. However, due to unexpected well problems and higher pore pressures, kicks were taken during drilling of the final production hole section. The drill string was packed off and stuck during one kick; the well was ultimately plugged back and sidetracked. After sidetracking, loss circulation occurred below the intermediate casing shoe, adding significantly to drilling time requirements. Fifty-two days, rather than the fourteen days originally projected for the hole section, were required to successfully reach total depth. The actual volumes of oil base cuttings and waste fluids generated were greater than originally estimated.

Figure 17 summarizes the volumes of cuttings, slurry, waste, waste fluids, and displacement volumes injected into the surface by intermediate casing annulus. Additionally, a record was also maintained to track the estimated volume of compacted waste generated on location. From December 20, 1991 to March 2, 1992, approximately 185 barrels of oil base cuttings were generated and slurrified. During initial injection tests, an estimated 1200 pounds of solid waste were processed through the mechanical shredder and were mixed into oil base cuttings slurry. The associated waste fluid volume was 5043 barrels; seawater displacement was 13330 barrels. As an added note, waste zinc bromide completion fluid and wash water were also injected into the annulus during the completion phase of operations. A total of 20,413 barrels of assorted fluids was injected into the casing annulus during the entire project.

Radioactive Tracer Results

During the introduction of cuttings slurry or any solids laden fluid into the pump suction, radioactive tracer was simultaneously injected into the pump suction to provide future confirmation of the projected injection point. Antimony was injected at the beginning of the injection process to establish the location of the initial injection zone, and was continued for the first one-third of the open hole interval. At approximately 11575', the radioactive tracer was changed to iridium to assist in determining whether any changes in the injection point had occurred as a result of the volumes and types of materials injected. At 12200' driller's depth, the radioactive tracer was again changed to scandium. Although well control problems surfaced, scandium injection was continued until all drilling and completion operations were completed. Handling of the radioactive tracer materials was restricted to licensed personnel. All operations were conducted in accordance with regulatory guidelines. Safety of personnel was never compromised.

Logging Results

In early February, 1992, the JB-3 well reached a total depth of 12654'MD. After setting a 5-1 /2" production liner, a multiple isotope tracer log was to run to identify injection points. The log section is illustrated in **Figure 18.** Results showed that residual radioactive materiel was present between the 10-3/4" x 7-5/8" annulus through the interval from 2300' to the surface casing shoe at 4990'. The magnitude of the gamma ray response was indicative of very small amounts of tracer material. It was concluded that the residual material was tracer-tagged cuttings concentrated in the low side contact points between the 10-3/4" and 7-5/8" casing in the angle build section. None of the hot spots correlated to any specific high permeability sand section. More notably, log results revealed that all cuttings, waste slurry, and waste water had been injected into the interval from 4910'-5000' into a large permeable sand section at the surface casing shoe. No bridging or plugging of deeper permeable sands or associated changes in injection point had occurred during any part of the injection process.

Equipment and Operational Results

The general process flow of cuttings, waste, and slurry through mechanical equipment was performed according to original plans. Once cuttings were received into the first stage blender, a combined slurry of oil base cuttings and waste products was processed repeatedly by the tungsten carbide centrifugal pumps until the desired density and rheology had been obtained. The slurry was then transferred to the second stage blender for continued processing, prior to transfer to the triplex pump skid. High pressure piping transported the slurry from the pump discharge to the injection wellhead for disposal into the subsurface formations.

Two problems with the mechanical shredder's performance were identified. First, the shredding process generated considerable dust. High winds experienced during testing dispersed dust onto the rig, creating a safety problem. Personnel feeding waste into the shredder were required to wear goggles and air masks. Modifications to the discharge outlet of the shredder are needed to eliminate the dust problem. Secondly, moisture was introduced into the shredder from food waste included with galley paper products. The moisture caused the ground paper waste to swell immediately upon shredding. This prevented the material from exiting through the retention screen at the base of the shredder. A wet sludge formed which could not be effectively discharged. As designed, the mechanical shredder was not suited for processing damp or wet materials.

One primary objective of the field test was to confirm the injectability of oil base cuttings slurry laden with shredded waste products into formations. The triplex pump used for injection purposes had 4.5" diameter X 5" stroke plungers. Suction valves were horizontally positioned. The pump was capable of pumping conventional oil base cuttings slurry, but the low valve clearance afforded by the small plunger size configuration proved inadequate for pumping shredded waste products. During actual injection operations, injection pressures and rates were 1200 psi at 1 BPM.

This created pump problems associated with bridging of waste solids, particularly the large pieces of the cement plugs, gaskets, and wood within the valve sections. This effectively halted injection operations.

In light of the problem, efforts were redirected toward utilizing the rig's cement pump skid. The HT-400 pumps on the cement skid were larger diameter, long stroke dual triplex units, i.e. 4.5' diameter X 8" stroke. The pumps have large valves and seats which provide greater valve to seat clearance. Both the suction and the discharge valves are mounted in the vertical position. Solids accumulations in the valve area are greatly reduced by this design configuration.

Transfer hoses were run to the cementing unit, and slurry was transferred to the measuring tanks. Radioactive tracer injection equipment was installed into the suction manifold of the cement pump to provide a means for tracer injection. After establishing initial injection, 100 barrels of oil base cuttings slurry laden with 7-10 pounds per barrel shredded wood, paper, and plastic materials were injected and displaced into the subsurface formation with no mechanical problems. No significant pressure increases were noted when the slurry entered targeted formations. The short term capability of effectively injecting assorted via waste into subsurface formations was confirmed.

Due to unfavorable economics and the need to secure better suited mechanical pumping equipment, the incorporation of waste products by processing materials through the shredder and into the cuttings slurry was discontinued. Utilization of the original triplex pumping equipment were re-initiated. The injection of oil base cuttings slurry and waste fluids proceeded without further incident for the remainder of drilling and completion operations.

Casing Contingency

Special provisions were incorporated at the wellhead to alleviate potential erosion of the 7-5/8" intermediate casing due to the injection of solids laden fluid. Extra long casing slips with wear skirts were installed as part of the intermediate casing wellhead installation. Adequate thickness was provided to withstand the continuous impingement by injection fluids. No erosional problems occurred with respect to the mechanical integrity of the wellhead injection system.

Plug and Abandonment

Upon completion, the 10-3/4" by 7-5/8" annulus was squeeze cemented using 200 sacks Class H cement per pre-approved permit criteria. The well was permanently identified with a sign indicating that the annular section had been used for disposal of oil base cuttings and non hazardous rig waste.

Data Collection and Sample Analysis

During the test period, nineteen samples of oil base cuttings slurry and assorted waste products were obtained for further lab analysis. Upon shipment to shore-based lab facilities, a wide variety of parameters were evaluated: physical appearance, settling characteristics, ease of re-suspension and stirring, smell, density, fluid rheology, and solids content. A complete particle size distribution was provided using both the screen sieve technique and the Malvern particle size analyzer. General results are summarized in the appendix.

COST

A cost comparison of cuttings injection versus using conventional land fill disposal was made prior to project start-up. The costs for conventional oil based cuttings disposal actually incurred on a recent well were used as the basis for cost analysis for the East Cameron 56 JB-3. For this well, oil base cuttings and waste/wash water were transported to base and were transferred to an approved disposal site. Actual disposal costs were as follows:

Cuttings disposal	$9.50/bbl.
Waste/wash water disposal	$3.50/bbl.
Dock labor	$15.00/hr.
Injection pumps	$60.00/hr.
Crane Rental	$120.00/hr.
Cuttings boxes	$15.00/box
Boat transportation	$1400/day

Applying these factors, the estimated cost for conventional disposal of oil base-cuttings for the East Cameron 56 JB-3 was projected as follows:

Cuttings disposal	130 bbls.
Waste/wash water disposal	1400 bbls.
Dock labor	24 hours
Injection pumps	24 hours
Crane Rental	12 hours
Cuttings boxes	20 boxes – 14 days
Boat Transportation	2 days
Total Estimated Costs	**$19,510**

Costs for specialty services required to complete both cuttings and waste injection were estimated as follows:

CUTWIP Implementation	$35,000
Radioactive tracer service	14,000
Multiple isotope tracer logging	48,000
Lab evaluation	15,000
Total Estimated Costs	**112,000**

Figure 19 shows planned and actual days versus depth drilling performance. The planned drilling time for the 6.5" production hole interval was 14 days. Significantly higher than anticipated pore pressure resulted in kicks, loss circulation, and stuck pipe which required sidetracking to reach the geologic objective. Once the intermediate casing shoe was drilled, 52 days were actually required to reach final total depth. Actual costs for specialty services were as follows:

CUTWIP Implementation	$181,066
Radioactive tracer service	51,036
Multiple isotope tracer logging	48,523
Lab evaluation	14,000
Total Project Cost	**$294,625**

Of this time frame, 25 days or approximately $103,100 of associated costs were incurred strictly for standby time for specialty equipment and personnel. The exploratory nature of the production hole section caused considerable drilling difficulty which created significant cost overruns associated with continued use of the cuttings injection option. Based on the actual volumes processed and drilling time required, the cost if conventional disposal of oil base cuttings had been used for the East Cameron 56 JB-3 is as follows:

Cuttings disposal	183 bbls.
Waster/wash water disposal	3817 bbls.
Dock labor	24 hours
Injection pumps	24 hours
Crane Rental	12 hours
Cuttings boxes	20 boxes - 52 days
Boat Transportation	2 days
Total Estimated Costs	**$46.067**

Obviously, a wide cost disparity exists between injection disposal and conventional disposal options. Other options which cannot be quantified but do add value to the merit of using the injection disposal option should also be considered. In the past, oil base drill cuttings have normally been transported to shore base for disposal at a waste site. This volume contributes significantly to the current landfill/waste problem. Disposal by on-site injection and disposal of cuttings and other wastes add value by contributing toward corporate long term commitment to protecting the environment.

The ability to safely offload cuttings boxes to a work boat during winter is contingent upon good weather. Drilling operations undertaken during winter in particular could be halted due to the inability to offload and transport cuttings boxes. A resultant shortage of boxes can occur on the drilling rip. One single day of such problems can add $35,000 - $50,000 to the total well cost; this possibility is also eliminated if cuttings injection is utilized.

Some improvements in terms of reduced boat transportation costs and improved operating efficiencies are reaped by the reduced logistical demand of less deck cargo going and coming to the rig. In a time when one work boat is routinely shared between multiple drilling and production operations, deck space for equipment commands a premium. The elimination of cuttings boxes eases boat transportation requirements.

Another significant item is cuttings box rentals. Far more boxes are required for the conventional disposal method than are required as backup for upset conditions if cuttings injection is utilized. The difference between having 10 boxes on board as backup for cuttings injection versus the 80 boxes which might be required for transport becomes an additional cost consideration. At a cost of 815.00/box/day, this equates to $1050/day rental cost offset by utilizing cuttings injection.

CONCLUSIONS/RECOMMENDATI0NS

1. The cost for utilization of the cuttings/waste injection process for drilling the production hole section of the East Cameron 56 JB-3 well was significantly greater than projected costs if conventional land based disposal had been utilized.

2. For exploratory wells and risky development wells, the merit of utilizing cuttings injection for oil base mud systems must be realistically compared to conventional disposal techniques. Limited geologic control can result in significant time and cost over-expenditures for use of the process.

3. The disposal of oil base cuttings and rig waste by slurrification and annular injection is a mechanically viable alternative to conventional land-based disposal.

4. Based on the limited volume of rig waste products injected, it appears that the addition of rig waste products such as mud sacks, visquine, cardboard, paper, and wood into the oil base cuttings slurry is not detrimental to disposal by annular injection, particularly in the highly porous, permeable sand horizons characteristic of Gulf of Mexico wells. However, injection with significantly greater volumes of assorted rig waste should be undertaken to better assess its total impact on long term, high volume injection longevity.

5. The mechanical shredding unit is well suited for shredding a wide variety of waste products generated on the drilling rig. The unit cannot process paper products or materials which are damp or wet. The introduction of such materials into the unit will result in clogging and total shut down of the shredder. Additional modifications to the retention screen must be incorporated to provide a means for quick removal of the screen to afford easier clean-out.

6. Injection pressures for fracture initiation were as projected by pre-job fracture analysis. Results of the fracture modeling proved invaluable for use in this environment, and should be adopted as standard protocol for any future efforts.

7. The use of radioactive tracers in conjunction with an appropriate logging program is an excellent method for identifying where the injection of oil base cuttings and waste products has actually occurred.

8. Small-plunger, short-stroke triplex pumps are adequate for pumping slurrified oil based cuttings, but are not able to effectively pump waste debris under intermediate differential pressures. Alternate means of pumping the composite slurry of oil based cuttings and shredded waste products must be identified.

9. Stacking multiple shredding units should be tested to determine whether the final particle size of processed waste materials could be further reduced. Based on results of the particle size analysis, paper products continue their degradation when processed through the centrifugal pumps. The plastic products exhibited no further degradation in size when comparing size discharged from the shredder to size introduced into the triplex pump prior to pumping into the casing annulus. The large particle size of the hard plastic waste may also prove detrimental to the longer term injection/disposal process.

10. Further degradation of both drilled solids and rig waste, primarily paper and visquine, was observed as a result of continued processing through the tungsten carbide centrifugal pumps. The process is obviously time sensitive. An end point determination of maximum required processing time must be made for specific waste products, varied shale densities, and material hardnesses.

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REFERENCE

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Sample Analysis Results

Samole 01: Shredded Waste Products. Paper and visquine were processed through the mechanical shredder strictly to provide samples for general distribution -purposes:

Samples #2. #3. *4. & #5: Slurrified Drilled Out Cement.
Intermediate casing (7-5/8') had been set at 10946'MD/10015'TVD. After tripping in the hole and preparing to drill out, the top of cement was tagged at 10650'MD. At this time, seawater which was used to bump the cement plug, was displaced with LVT-200 oil base mud prior to drilling cement. Approximately 12.6 barrels of cement and two wiper plugs were drilled from the interval 10650' to 10946'; cement cuttings were incorporated into a gel slurry formulation for disposal. The slurry density for sample x2 was 10.39 ppg; the slurry was very thick. Sample #2 was diluted with drill water, and sample #3 was obtained. The slung density for sample #3 was 9.38 ppg as a result of the dilution required to improve overall pumpability. Solids content by weight for samples #2 and A'3 ranged from 24-37%; solids content by volume were 14-21 %. Samples x4 and x5 were further diluted versions of x2 and #3 prepared in an effort to overcome pump problems associated with pieces of rubber lodging in the pump valves.

Samples #6 & #7: Ground Up Paper Waste. Mud sacks and cardboard boxes were processed through the mechanical shredder and were incorporated into a slurry. Sample #6 was obtained for exhibit purposes; sample #7 was used for lab analysis. The shredder easily processed assorted paper products. The retention screen located at the bottom of the unit worked as expected provided no damp or wet paper products were introduced. Feeding either of these materials or any food waste into the unit caused the cellulose to swell rapidly after shredding before the material could be discharged through the retention screen. Considerable processing time was required to remove waste material from the bottom of the shredder, once it became clogged with wet/damp materials. The loose density of the processed paper waste was 2.49 ppg. The compressed density was 4.09 ppg. Of the paper products processed, 93.4% of the material was 12 mesh (1680 micron) in size or larger, with 54.7% in the 6 mesh 13360 micron) size or larger prior to introduction into any slurry.

Samples x8 & #9: Ground Up Visquine Plastic. Visquine plastic was processed through the shredder with no problems. Sample x8 was obtained for exhibit purposes; sample x9 was used for analysis. Some small paper pieces were evident from the previous processing in both samples, but were not significant in volume. The loose density of the processed visquine was 2.00 ppg; the packed density was 3.25 ppg. Of the visquine processed, 73.4% of the material was 12 mesh (1680 micron) in size or larger, with 42.0% in the 6 mesh (3360 micron) size or larger prior to introduction into the slurry.

Samples #10. #11. & #12: 10 ppg Bentonite + Waste Products.
Sample i10 was a slurry composed of drill water and 10 PPB bentonite, plus an estimated 5 ppb paper and 5 ppb visquine. The slurry density was 8.87 ppg, reflecting an absence of either cement particles or oil based drill cuttings. Solids content by weight were 3.4%; solids content by volume were 1.0%. Of the solids, 75.4% were 100 mesh (149 micron) or less in size. Sample x11 reflects the addition of 1 sack of gel to the slurry to provide additional viscosity, combined with 30 minutes additional processing by the centrifugal pumps. Of the solids, 77.1 % were 100 mesh or smaller. Sample #12 reflects an additional 20 minutes processing time. Of the solids, 82.8% were 100 mesh or smaller. Further degradation of solids, both paper and visquine, were observed as a result of additional processing through the tungsten carbide centrifugal pumps. The process is obviously time sensitive.

Samples x13 & #14: Gelled Water with Oil Base Cuttings: No Waste.
Sample #13 was conventional oil base cuttings as normally processed for annular injection. The slurry density was 10.29 ppg, reflecting an optimum solids:water ratio of 1:3. Solids by weight were 28.9%; solids by volume were 14%. Of the oil base cuttings processed, 91.0% were 100 mesh (149 micron) or smaller in size. Sample #14 represents continued overnight processing of the slung through the centrifugal pumps. Of the oil base cuttings processed, 95.9% were 100 mesh or smaller in size.

Sample #15: Clean OBM Cuttings Slurry. Sample t15 was a conventional oil base cuttings slurry prepared to accommodate the addition of a wide variety of waste products, i.e. paper, visquine, plastics, and wood. The oil based cuttings slurry density was 10.39 ppg. Solids content were 26.9% by weight, and 10% by volume; of the solids 100% were 35 micron or smaller.

Samples #16 & #17: Ground Up Wood Products and Plastics Added.
Wooden pallet material and crates were processed through the shredder and were incorporated into the sample x15 slurry formulation. For sample x16, the wood density was 2.36 ppg loose, 3.67 ppg packed. For sample # 17, the plastic particle density was 3.07 ppg loose, 4.25 ppg packed. The combined material was composed of coarse to fine wood chips with assorted hard plastic chips (plastic buckets) scattered throughout.

Samples x18 & #19: Slurry with Waste/Diluted. Sample #18 was a combination of oil based cuttings, with wood, paper, and plastic wastes added. The slurry density was 9.87 ppg; slurry was extremely thick. Rheology of the slurry could not be determined due to binding of the bob on the VG meter. Approximately 91 % of the combined solids were 100 mesh (149 micron) in size or smaller. Slurry !19 was a diluted formulation of x18, to improve pumpability. The slurry density, with the addition of water, was 10.08 ppg. Particle size analysis was unchanged from ar18 configuration.

SI METRIC CONVERSION FACTORS

I barrel (bbl) = 0.1589 m3
1 foot (ft)' = 0.3048 m
.345- pound per gallon- (ppg) = 1000 kg/m3
1 pound (lb) = 0.453 kg
1 pound per square inch = .069 Bar

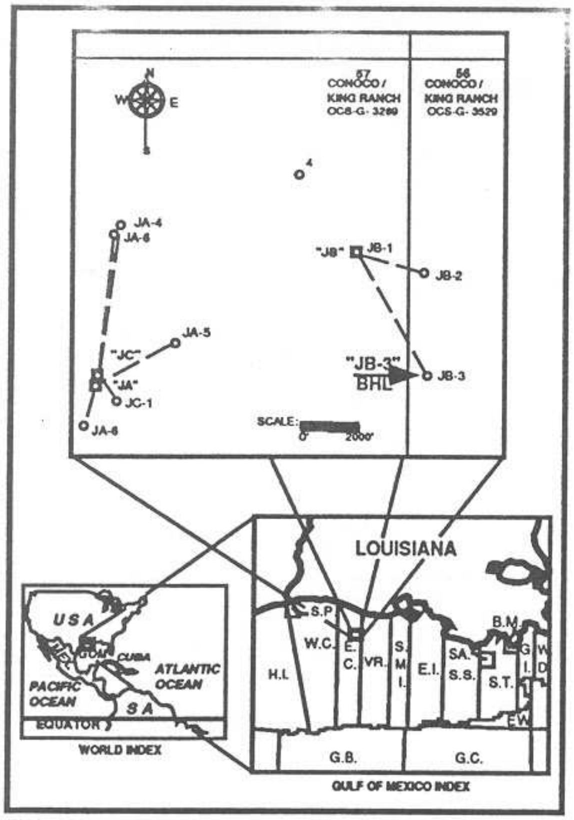

FIGURE 1: East Cameron 56 JB-3 Location Plat

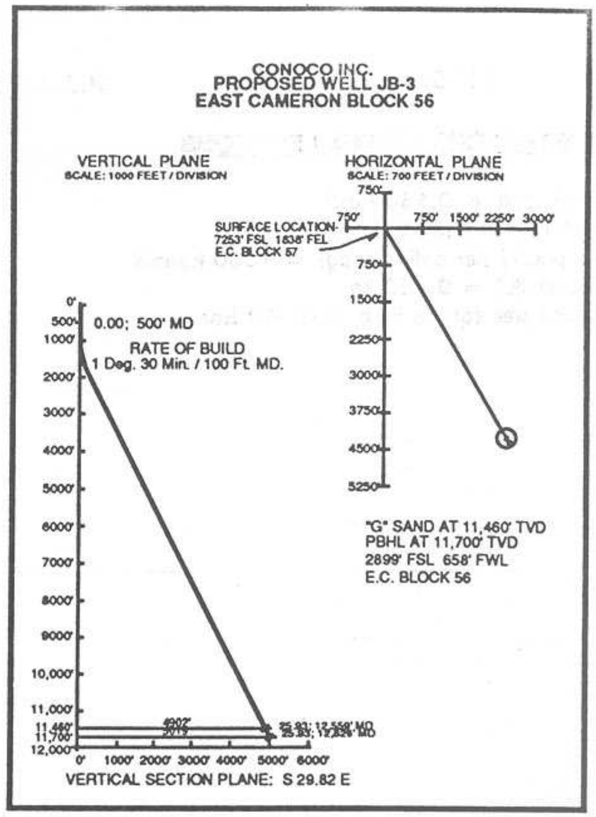

FIGURE 2: East Cameron 56 JB-3 Directional Plan

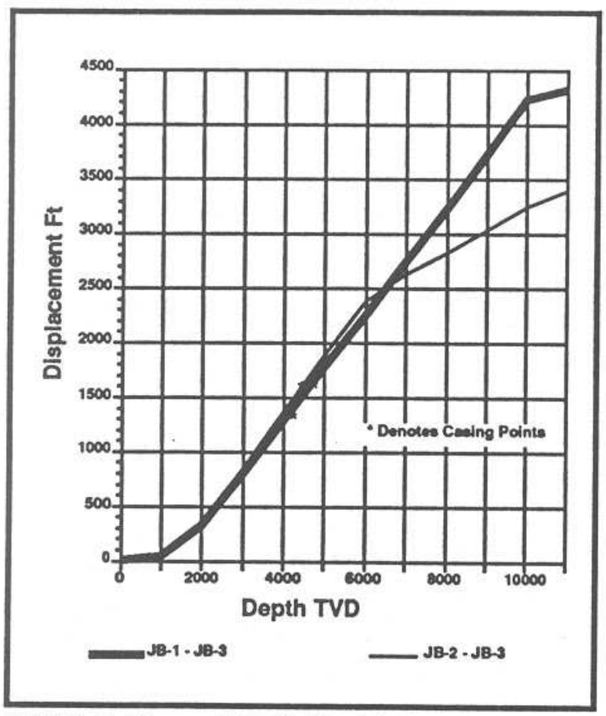

FIGURE 3: East Cameron 56 / 57 Well Proximity Comparisons

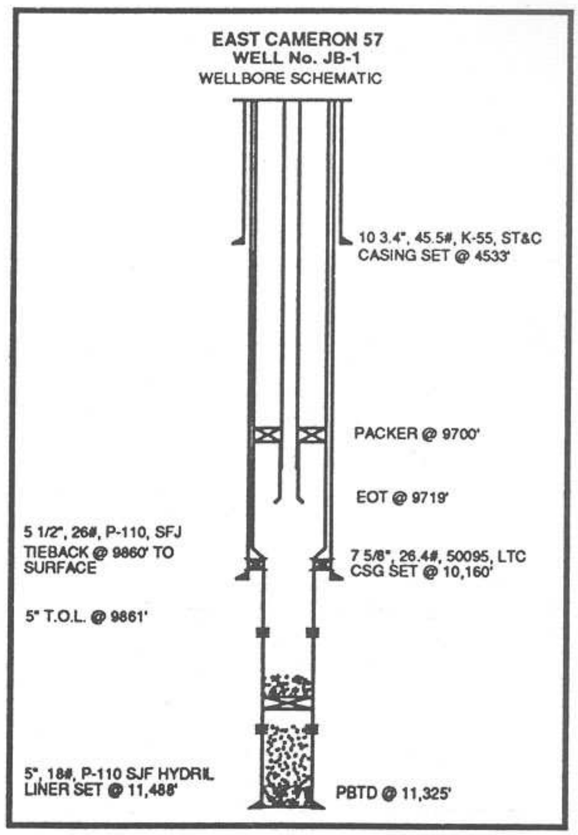

FIGURE 4: East Cameron 57 JB-1 Wellbore Schematic

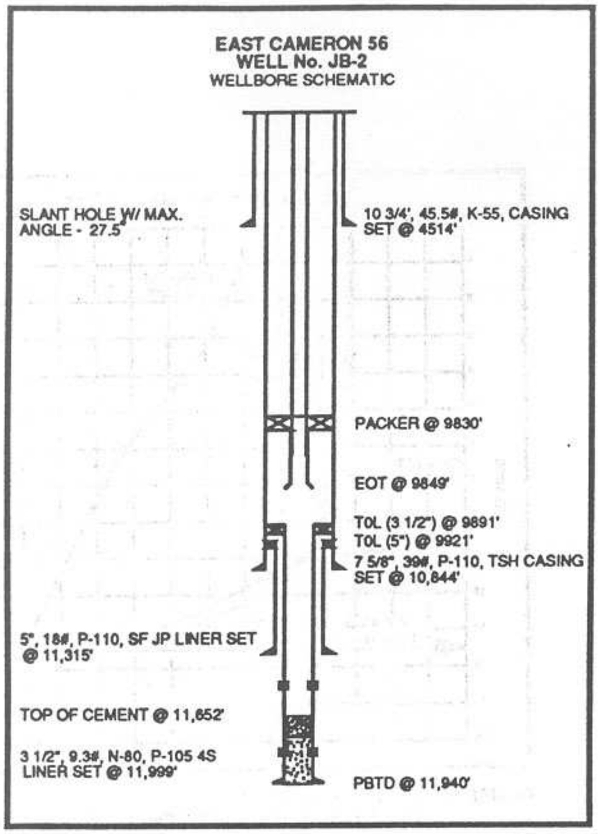

FIGURE 5: East Cameron 56 JB-2 Wellbore Schematic

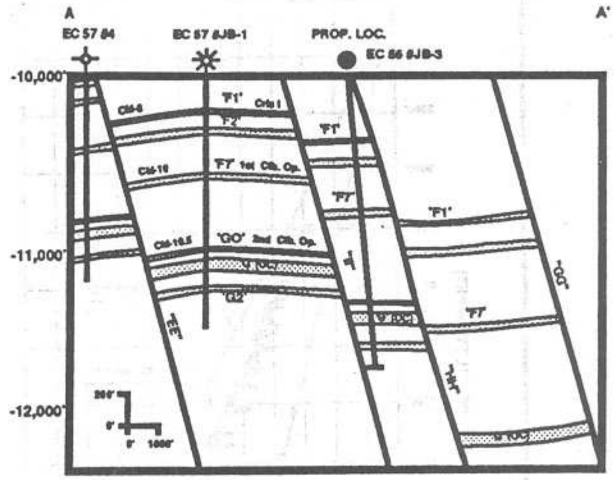

FIGURE 6: East Cameron 56 / 57 Seismic Cross - Section

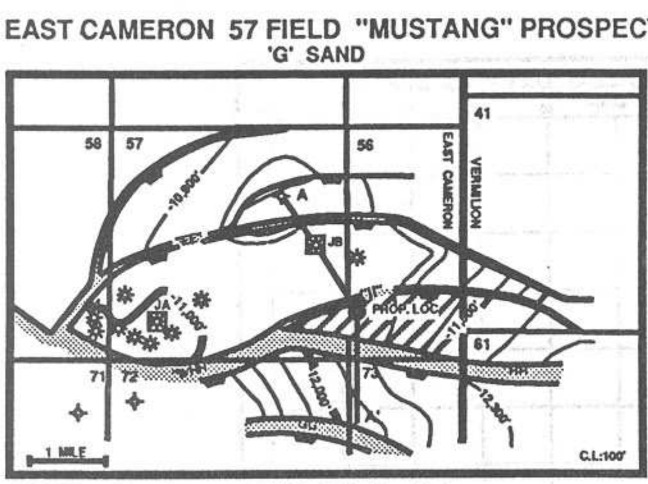

FIGURE 7: East Cameron 56 / 57 Objective Horizon

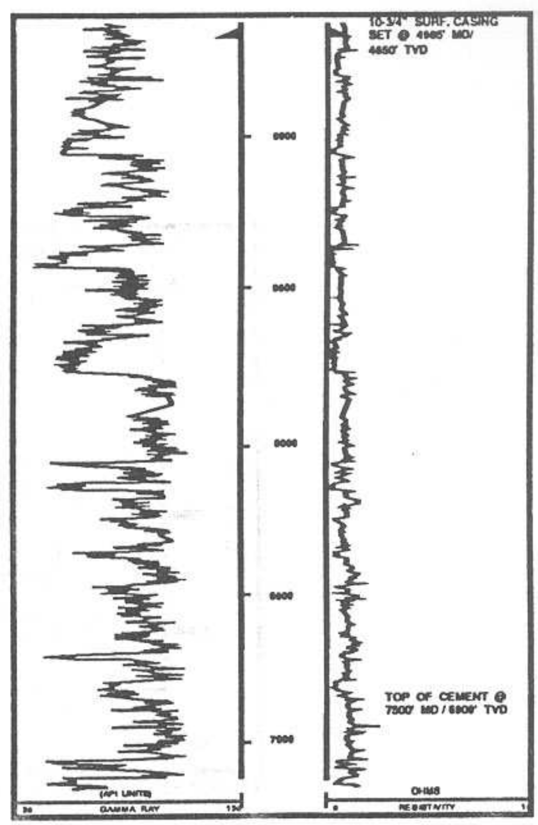

FIGURE 8: East Cameron 57 JB-1 Log Section

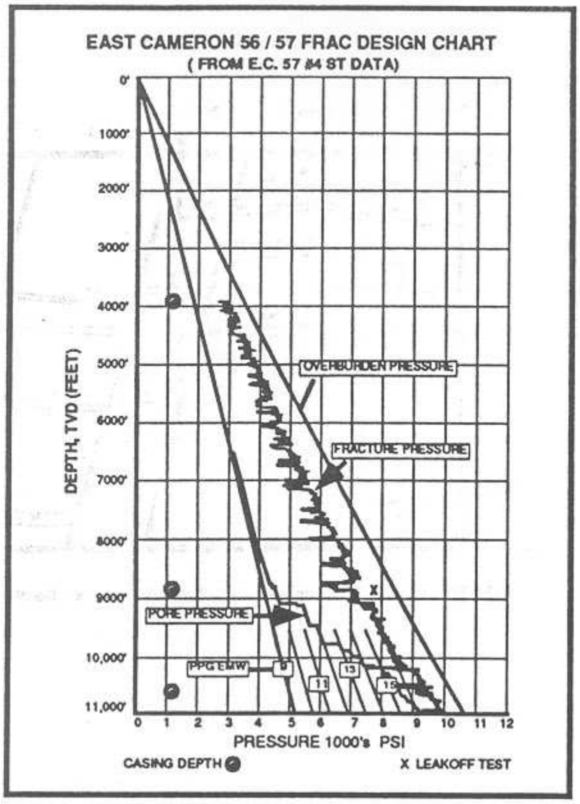

FIGURE 9: East Cameron 56 / 57 Frac Design Chart

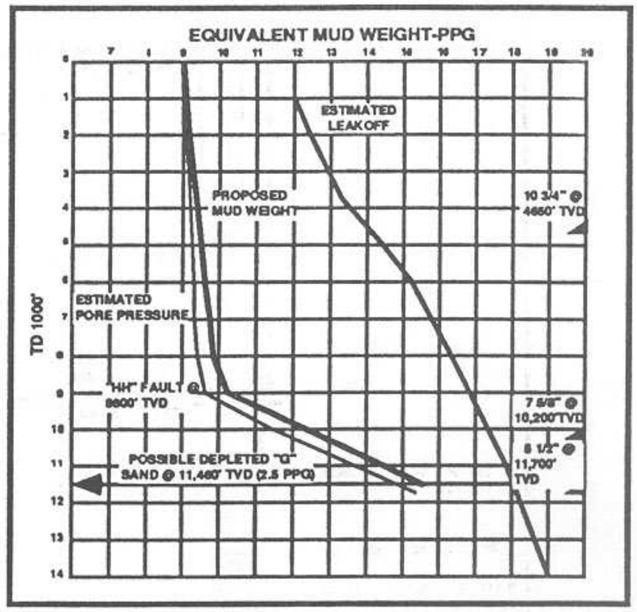

FIGURE 10: East Cameron 56 JB-3
Pore Pressure, Mud Weight, Fracture Gradient Versus Depth

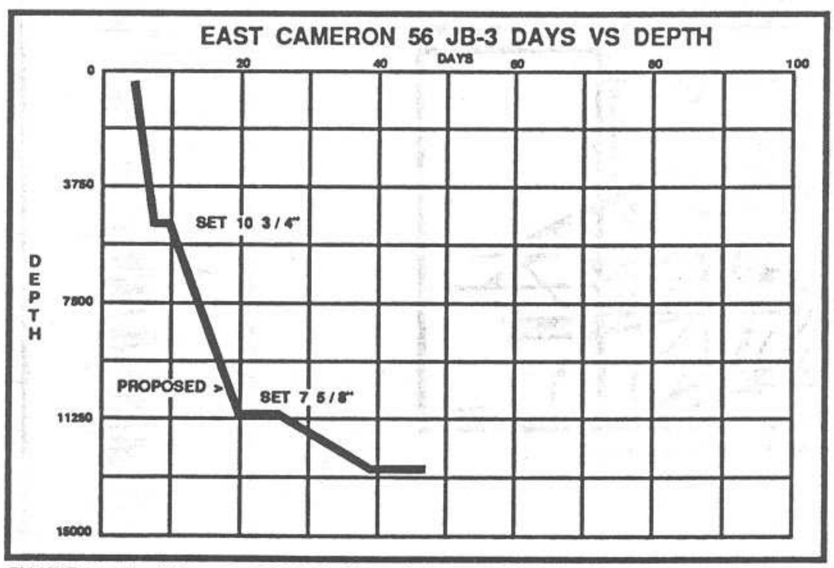

FIGURE 11: East Cameron 56 JB-3 Planned Days vs Depth Drilling Performance

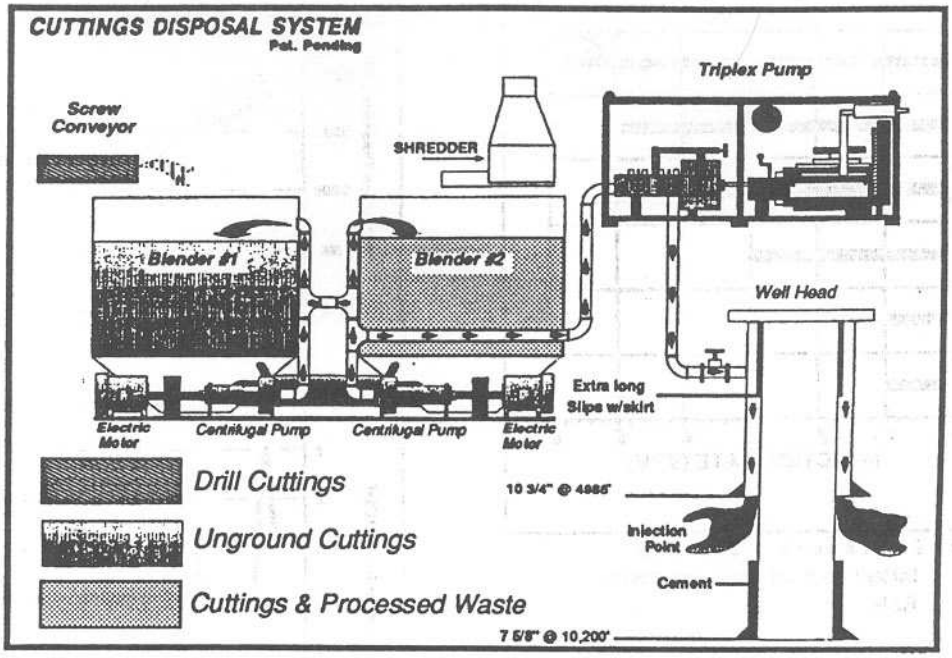

FIGURE 12: East Cameron 56 JB-3 Mechanical Flow Schematic

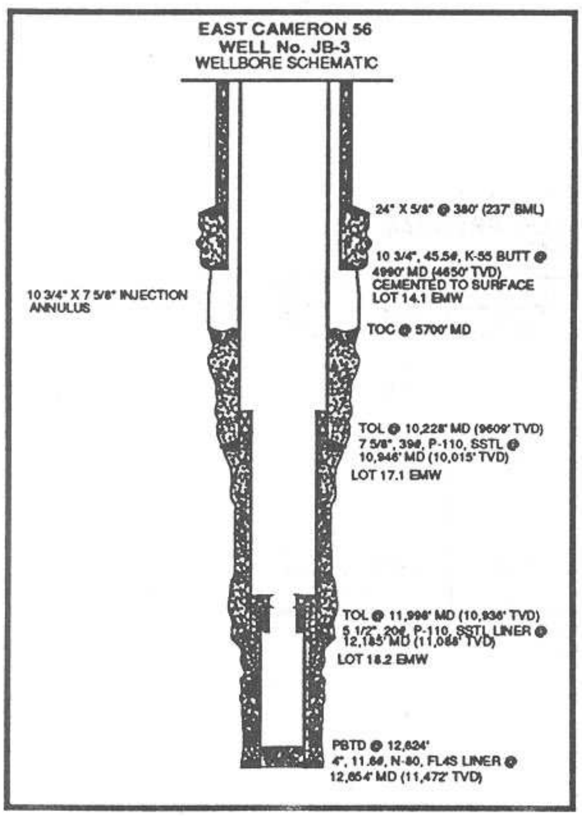

FIGURE 13: East Cameron 56 JB-3 Wellbore Schematic

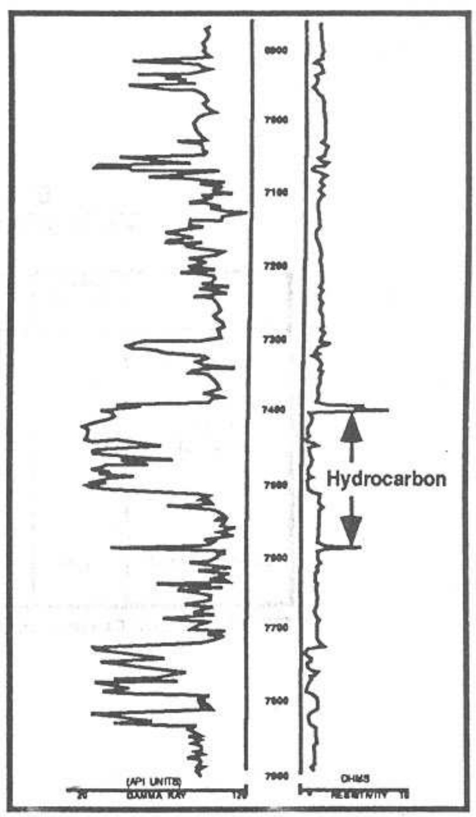

FIGURE 14: East Cameron 56 JB-3 Intermediate Hole Log Section

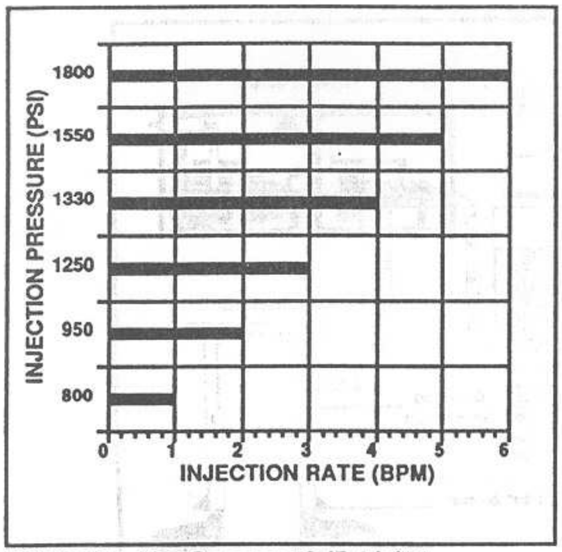

FIGURE 15: East Cameron 56 JB-3 Inital Inital Injection Pressure Versus Rate

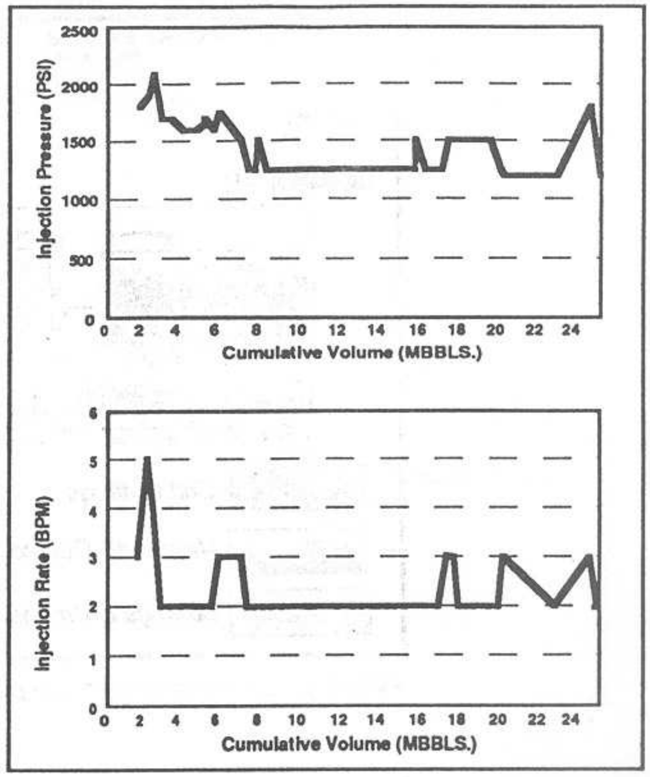

FIGURE 16: East Cameron JB-3 Injection Rates/Pressures Versus Cumulative Volume Injected

EAST CAMERON 56 JB-3
CUTTINGS / WASTE INJECTION PROGRAM
PROJECT SUMMARY

	CUTTINGS VOLUME (BBLS.)	SURREY VOLUME (BBLS.)	WASTEWATER VOLUME (BBLS.)	SEAWATER DISPLACEMENT (BBLS.)	COMPACTED WASTE (LBS.)	FOOD WASTE (LBS.)
WATER BASE SECTION	3621	0	1226	350	10895	2910
OIL BASE SECTION	183	2040	3817	12980	18615	6210
GRAND TOTALS	3804	2040	5043	13330	29510	9120

FIGURE 17: East Cameron 56 JB-3 Waste Volumes Injected

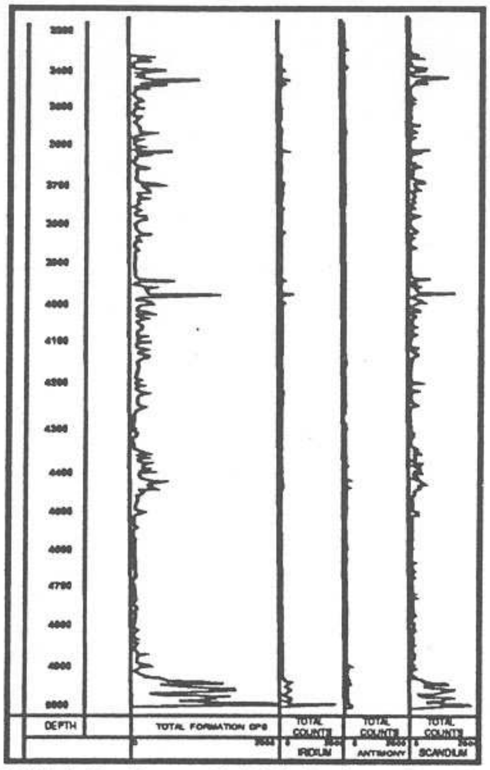

FIGURE 18: East Cameron 56 JB-3 Multiple Isotope Tracer Log

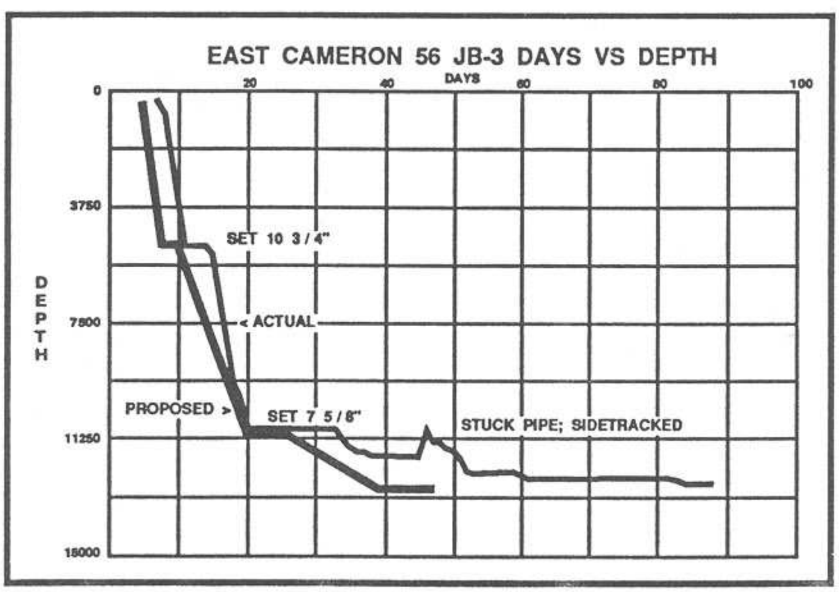

FIGURE 19: East Cameron 56 JB-3 Proposed Days vs Depth Drilling Performance