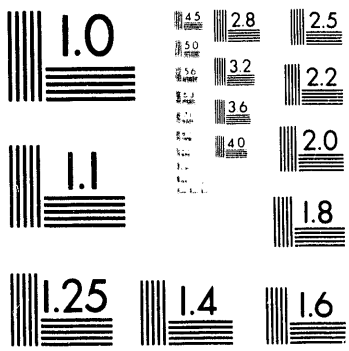
1.0
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1 of 1

2

DOE/BC/14861--1

Technical Progress Report

Horizontal Oil Well Applications and Oil Recovery Assessment

DOE Contract No.: DE-AC22-93BC14861

Submitted By:
Maurer Engineering Inc.

Contract Date: June 3, 1993
Completion Date: June 2, 1994

Principal Investigator: William J. McDonald
Project Engineer: Greg Deskins
Contracting Officer's Representative: Thomas B. Reid

Report for the Period
July — September 1993

Technical Progress Report

Objectives

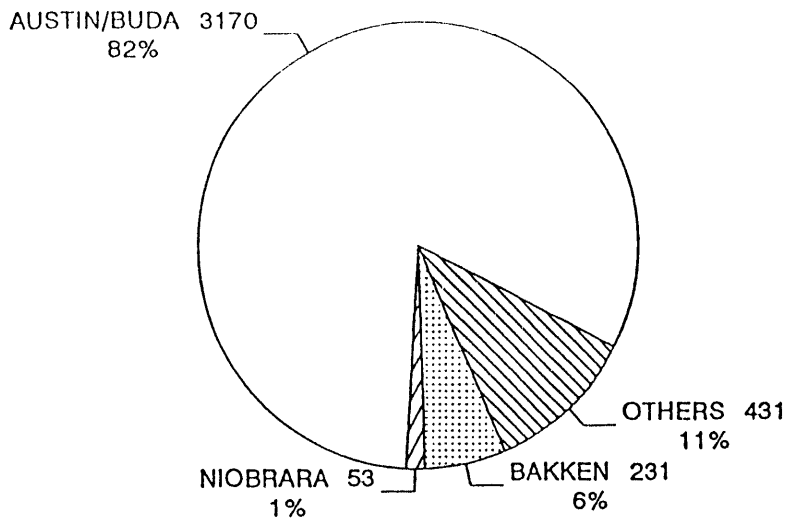
Thousands of horizontal wells are being drilled each year in the U.S. and around the world. Horizontal wells have increased oil and gas production rates to 3 to 8 times those of vertical wells in many areas and have converted non-economic oil reserves to economic reserves. However, the use of horizontal technology in various formation types and applications has not always yielded anticipated success.

The primary objective of this project is to examine factors affecting technical and economic success of horizontal well applications. The project's goals will be accomplished through five tasks designed to evaluate the technical and economic success of horizontal drilling, ascertain its limitations, and outline technical needs to overcome these limitations. Data describing operators' experiences throughout the domestic oil and gas industry will be gathered and organized. MEI databases containing detailed horizontal case histories will also be used. All these data will be categorized and analyzed to assess the status of horizontal well technology and determine the impact of horizontal wells on present and future domestic oil recovery and reserves.

Summary of Technical Progress

Information Base on Horizontal Wells

A spreadsheet data file was constructed from well data describing 3885 domestic horizontal wells, the total as of the summer of 1993. Most domestic effort in horizontal drilling has been focused on fractured carbonate formations. Three principal formations are the focus of this activity: the Austin Chalk in Texas, the Bakken Shale in North Dakota, and the Niobrara in Colorado and Wyoming. Results from this formation type are well known and a large volume of published results is available. Given the scope of the present study, it was decided to limit the analysis to formations other than these three fractured carbonates. Based on domestic well data, 431 horizontal wells have been completed in other formations (Figure 1). These wells were highlighted for detailed study.



* THROUGH DEC., 1992

Figure 1. U.S. Horizontal Well Distribution

About 180 operators drilled these other wells in a total of 112 formations. Contacts were located for 150 of these companies, who were telephoned about the project and sent a questionnaire. A copy of the project questionnaire is presented in Attachment A. No names or addresses could be tracked down for the remaining operators. As of the end of the reporting period, questionnaires covering almost half of the wells have been returned.

An extensive review of the literature was conducted on the wells of interest. Over 70 technical articles were reviewed and analyzed for data pertinent to the study. Information from these articles is being compiled into a comprehensive discussion of horizontal applications to be included as a section of the final project report.

Specialized Database for Horizontal Well Forecasting

A database for the questionnaire formation data was constructed in dBASE IV. A computer data entry form with the same format as the questionnaire was developed to facilitate data entry. Questionnaires have been received from several sources including operators listed in the original well data file, participant companies in the DEA-44 Horizontal Well Technology joint-industry project, attendees of the Horizontal Technology Forum held in Calgary during July 1993, and attendees of the Horizontal Technology Forum held in Houston during September 1993.

Over 160 records (one for each returned questionnaire) have been generated. A few questionnaires have been returned describing formations outside the scope of this study, including Austin Chalk wells and wells outside the U.S. These data may be evaluated and compared at a later date.

Economic and Technical Trend Analysis

Preliminary analyses have been performed on the database. Two types of trends are being examined in the horizontal well data. Overview analyses will determine the types and frequency of the various applications of horizontal technology (fractures, thin beds, low permeability, EOR, etc.). Preliminary results are shown for 48 formations in Figure 2. Multiple responses were typical; therefore, the results shown in the figure sum to more than 100%. The three most common applications include intersecting fractures (52%), delaying coning (35%), and economics (31%).

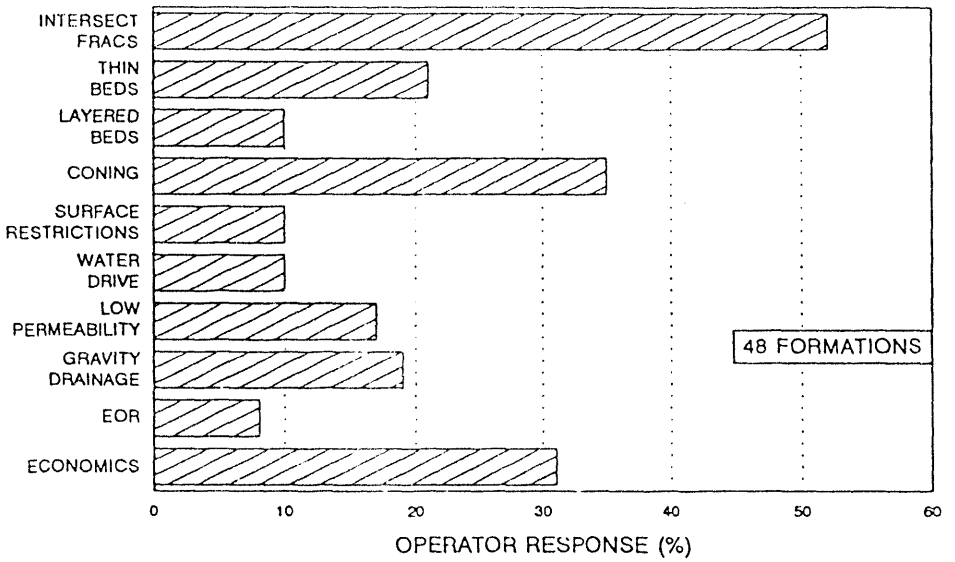


Figure 2. Horizontal Technology Applications

Average production and cost ratios for horizontal as compared to vertical will be computed. Trends will also be examined within various application subsets. For example, early results show that less than 40% of "Intersect Fracture" applications reported economic success.

Final analyses of technical and economic trends will proceed rapidly after all questionnaire data are received and entered.

Horizontal Well Application Forecast

Another key parameter in the questionnaire data is the estimated increase in reserves from horizontal technology. Preliminary results from 38 questionnaires (Figure 3) show that half of the operators expect no increase in reserves as a result of drilling horizontal wells in their particular field. However, the next most common response was an increase in the range of 16-25%. In a significant number of applications, horizontal wells are expected to increase recoverable reserves through, for example, delaying the onset of water coning or accessing oil not economically recoverable with vertical wells.

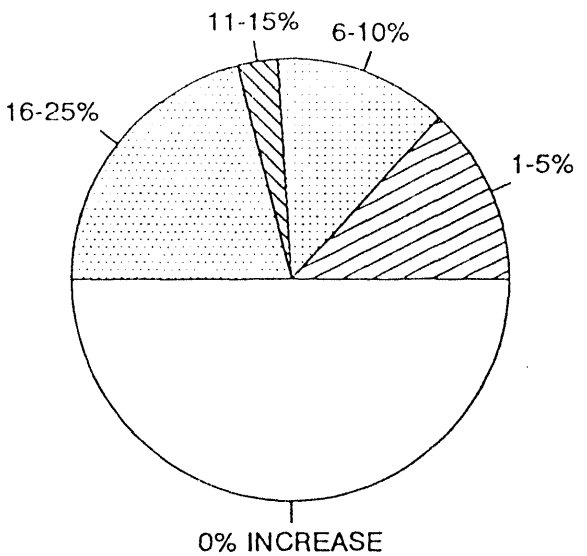


Figure 3. Reserves Increase with Horizontal Wells (38 Responses)

Final survey results are expected to yield interesting trends. The DOE has been queried regarding the best numbers to use for oil-in-place estimates for forecasting the overall effect of horizontal wells on domestic reserves.

William J. McDonald
Principal Investigator

Attachment A

HORIZONTAL WELL PRODUCTION QUESTIONNAIRE

PLEASE COMPLETE FOR EACH FIELD (MAKE COPIES IF NECESSARY).

NAME:_____ COMPANY: _____

ADDRESS:_____ FAX NO.: _____

FIELD:_____ FORMATION: _____

LITHOLOGY: _____ STATE: _____ COUNTY: _____

1. NUMBER OF HORIZONTAL WELLS DRILLED: ☐ 1-4 ☐ 5-10 ☐ 11-25 ☐ 26-50 ☐ >50 _____
   APPROXIMATE NUMBER OF NEW WELLS _____; APPROXIMATE NUMBER OF RE-ENTRIES _____
2. TYPE OF APPLICATION: (Check all applicable)
   - ☐ INTERSECT FRACTURES
   - ☐ THIN BEDS (Increase production rate)
   - ☐ LAYERED BEDS (Establish communication)
   - ☐ MINIMIZE CONING (Water, gas, etc.)
   - ☐ SURFACE RESTRICTIONS (Lakes, bldgs., etc.)
   - ☐ IMPROVE WATER DRIVE/WATER INJECTION
   - ☐ LOW PERMEABILITY (Poor fracture candidate)
   - ☐ IMPROVE GRAVITY DRAINAGE
   - ☐ ENHANCED OIL RECOVERY (Steam, polymer, etc.)
   - ☐ FAVORABLE ECONOMICS OVER VERTICAL

   COMMENTS _____
3. PRIMARY OBJECTIVE: ☐ REDUCE COST (vs. vertical) ☐ INCREASE PRODUCTION RATE ☐ INCREASE RESERVES
4. HORIZONTAL TO VERTICAL PRODUCTION RATIO: ☐ 1:1 ☐ 1.5:1 ☐ 2:1 ☐ 3:1 ☐ 4:1 ☐ 5:1 OTHER __
5. HORIZONTAL TO VERTICAL COST RATIO: ☐ 1:1 ☐ 1.25:1 ☐ 1.5:1 ☐ 1.75:1 ☐ 2:1 ☐ 2.5:1 ☐ 3:1 OTHER __
6. WERE HORIZONTAL WELLS A TECHNICAL SUCCESS? YES ☐ NO ☐ COMMENTS: _____
7. WERE HORIZONTAL WELLS AN ECONOMIC SUCCESS? YES ☐ NO ☐ COMMENTS: _____
8. WERE ANY OF THESE HORIZONTAL WELLS STIMULATED? YES ☐ NO ☐
   TYPE OF STIMULATION: ☐ FRACTURE ☐ MATRIX (Acid, washing, etc.)
9. INCREASE IN RESERVES DUE TO HORIZONTAL: _____% ☐ 0% ☐ 1-5% ☐ 6-10% ☐ 11-15% ☐ 16-25%
10. PLEASE DESCRIBE YOUR FUTURE HORIZONTAL ACTIVITY: ☐ NONE ☐ DECREASE ☐ SAME ☐ INCREASE
11. WHAT DEVELOPMENT(S) WOULD INCREASE THE USE OF HORIZONTAL WELLS IN YOUR FIELDS? _____
12. WHAT HORIZONTAL WELL PRODUCTION PROBLEMS HAVE YOU ENCOUNTERED?:
    - ☐ ARTIFICIAL LIFT
    - ☐ CEMENT PROBLEMS
    - ☐ COMPARTMENTALIZATION
    - ☐ FORMATION DAMAGE
    - ☐ FORMATION HETEROGENEITY
    - ☐ LOGGING (Prd., MWD, Other)
    - ☐ RESERVOIR MODELING
    - ☐ SAND CONTROL
    - ☐ SCALE OR CORROSION
    - ☐ STIMULATION
    - ☐ WATER OR GAS CONING
    - ☐ WORKOVER PROBLEMS

    COMMENTS: _____
13. WOULD YOU LIKE A SUMMARY OF THE SURVEY RESULTS? ☐ YES ☐ NO

    COMMENTS (Include additional sheets if necessary) _____

PLEASE RETURN FORM BY FAX TO MAURER ENGINEERING INC. AT FAX: (713) 683-6418 PH.: (713) 683-8227

DATE

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END