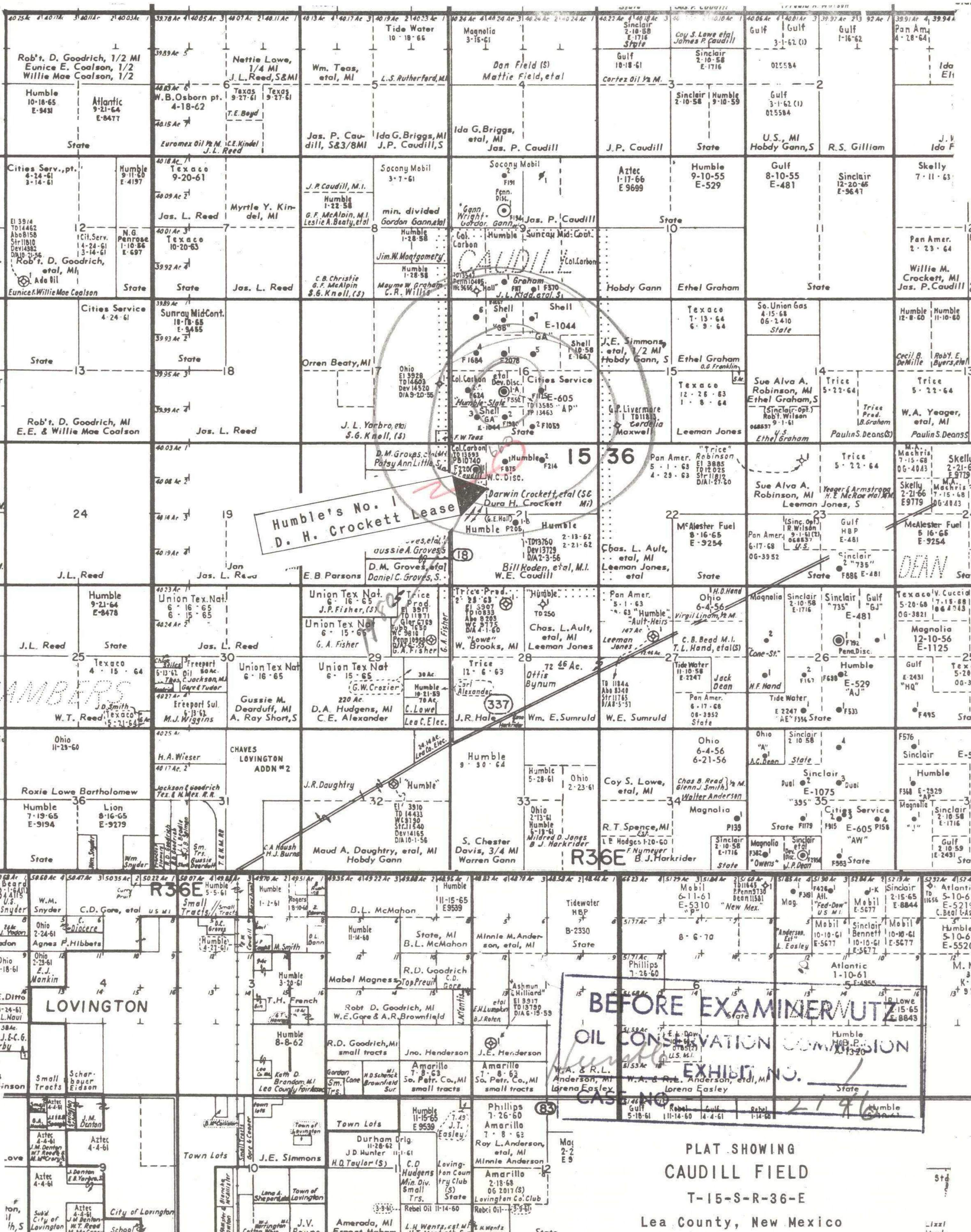
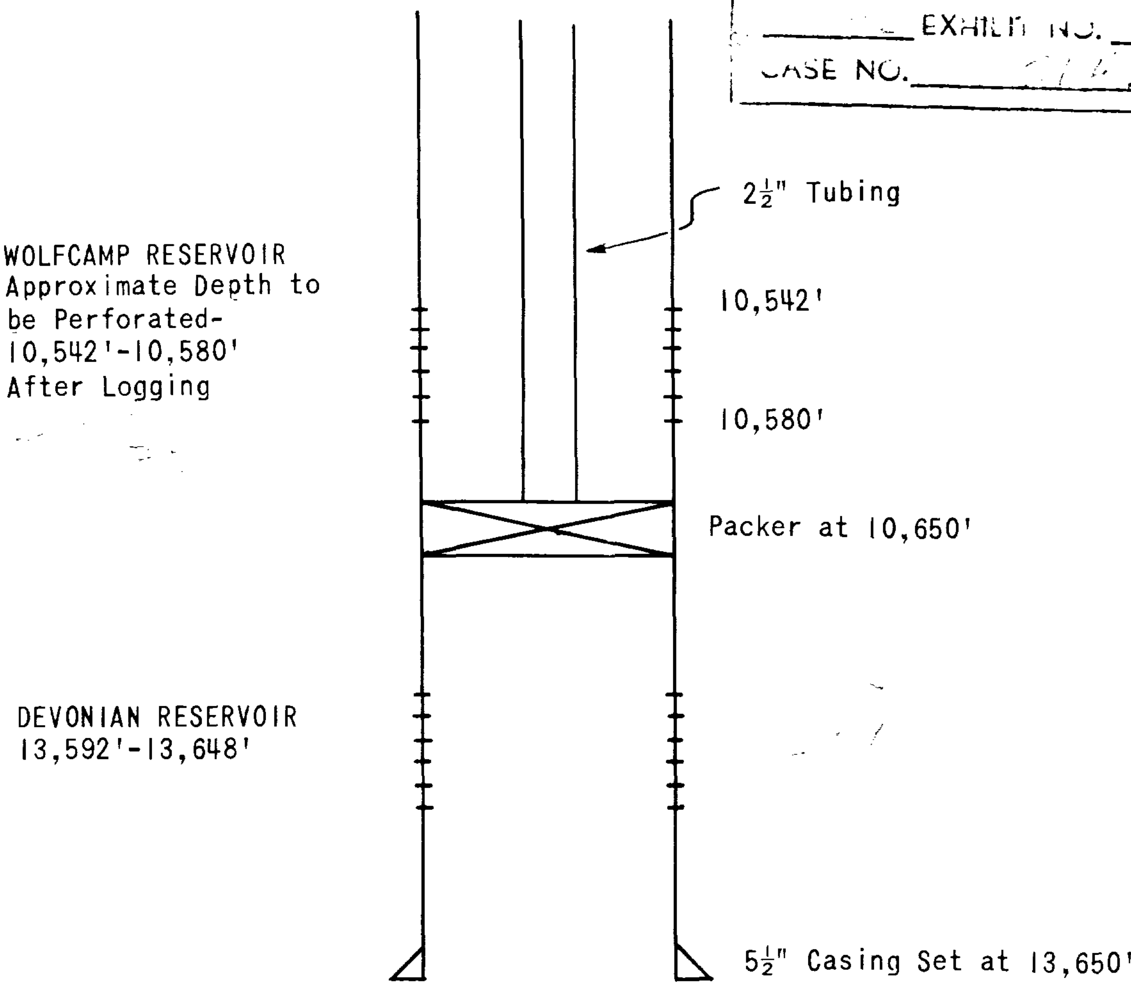


PLAT SHOWING
CAUDILL FIELD
T-15-S-R-36-E
Lea County, New Mexico

BEFORE EXAMINER NUTZ
OIL CONSERVATION COMMISSION
Humble EXHIBIT NO. 1
CASE NO. 2146

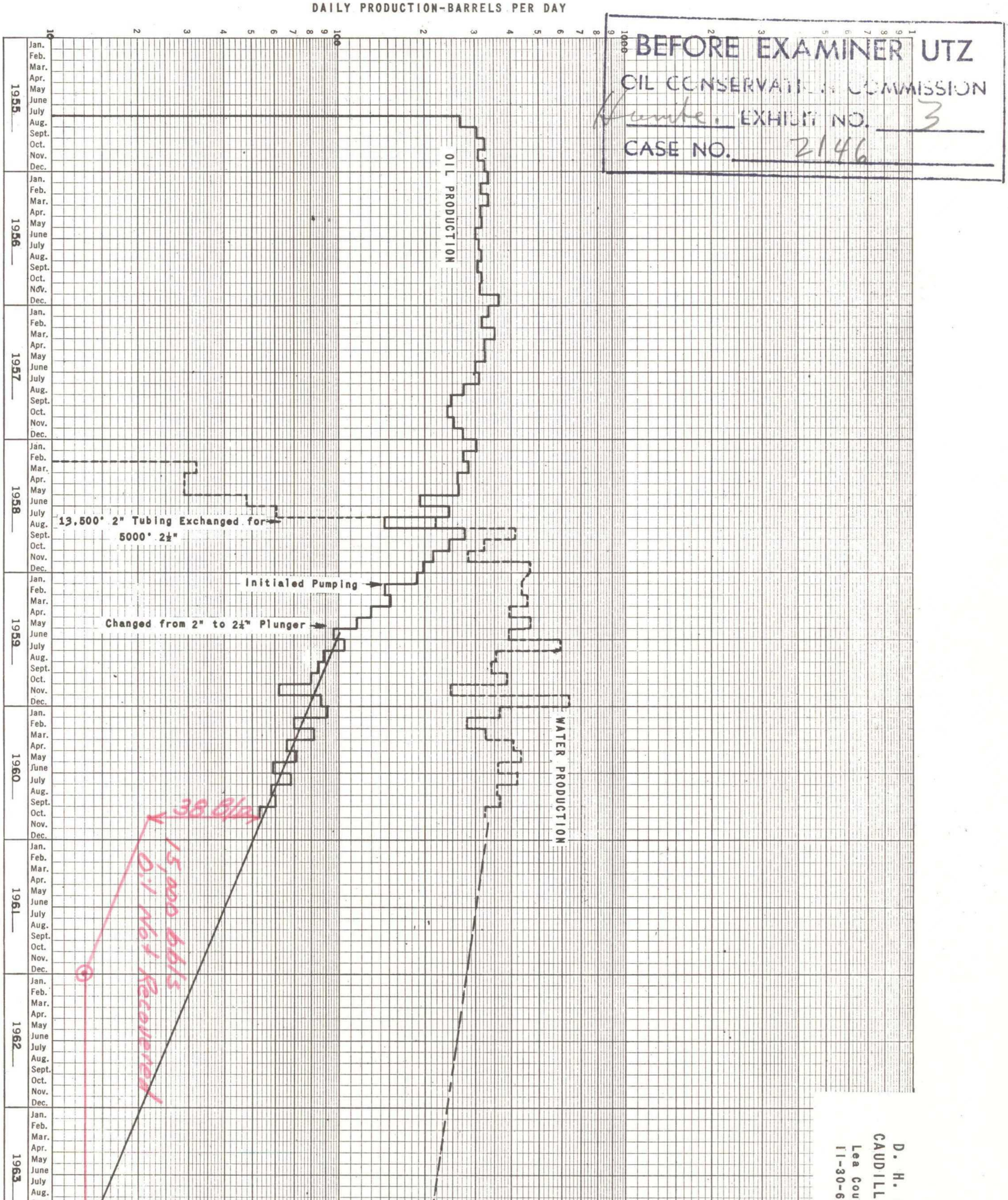
D. H. CROCKETT 1
CAUDILL FIELD



TOP OF CEMENT - 3700 FT.

PROCEDURE

1. After Logging, perforate indicated pay from approximately 10,542-80'.
2. Set non-retrievable packer at 10,650'.
3. Run 2½" tubing with a seating nipple and sliding sleeve valve two joints above the packer.
4. Set a blank off plug in the seating nipple, open the sleeve and acidize the Wolfcamp Reservoir.
5. Swab the Wolfcamp until flow is initiated, close the sliding sleeve valve and produce through the annulus.
6. Run rods and return the Devonian to production.



BEFORE EXAMINER UTZ
OIL CONSERVATION COMMISSION
Humble EXHIBIT NO. 3
CASE NO. 2146

D. H. CROCKETT NO. I
CAUDILL DEVONIAN FIELD
Lea County, New Mexico
11-30-60
W.G.D.

RECENT WELL TESTS OF DEVONIAN RESERVOIR

D. H. CROCKETT 1, CAUDILL FIELD

Date	Method of Production	Barrels Per Day: Salt Water	Barrels Per Day: Oil	Barrels Per Day: Total Fluid
10-16-58	Pump	352	235	587
11-26-59	Pump	512	70	582
1-2-60	Pump	511	90	601
10-12-60	Pump	439	60	499

Top allowable for the Devonian Reservoir - 272 Barrels per Day.

BEFORE EXAMINER UTZ
OIL CONSERVATION COMMISSION
EXHIBIT NO. [illegible]
CASE NO. [illegible]

ARTIFICIAL LIFT CAPACITY

Tubing Size -Inches	Pumping Fluid Level - Feet	Method	Capacity Bbls./Day
2-1/2	10,650	Rod*	260*
2-1/2	10,650	Subsurface Hydraulic	336
1-1/2	10,650	Rod*	80*
2-1/2	5,000	Rod	602
2-1/2	5,000	Subsurface Hydraulic	550
1-1/2	5,000	Rod	210

* - Special High Tensile Rods

Note: All capacities were determined using a volumetric efficiency of 80 percent.

,000

BEFORE EXAMINER UTZ
OIL CONSERVATION COMMISSION
_________ EXHIBIT NO. ____
CASE NO. ____________

MULTIPLE COMPLETIONS

The term "Multiple Completion" refers to the technique which permits two or more reservoirs to be produced simultaneously but separately through the same well bore. Although most multiple completions are used only for production, many wells of this type serve as multiple injection wells for pressure maintenance or secondary recovery projects, and others are used for the injection of fluid into one or more reservoirs while maintaining production from others.

Technical reports are available on dual completions made during the late 1930's; (10);however, there was no significant application of the technique prior to World War II. The wartime demand for petroleum products and the critical shortage of steel for tubular goods prompted increased utilization of dual completions during the 1940's (11), (Fig. 12). Early dual completions were limited essentially to flowing wells selected to present no problems such as sand production or high pressure. Tools and equipment designed for use in single completions did not perform satisfactorily when subjected to the more severe loading imposed by dual completions; however, in wells where conditions were ideal, the dual completion proved to be a successful tool, offering savings of about 45 percent in steel consumption and approximately 40 percent in drilling costs as compared to the drilling of two single wells. (12). Because general experience with dual completions during this period was not entirely satisfactory, a decline in use of the technique occurred during the period 1946 to 1949.

The increasing cost of drilling wells and the relatively low additional cost of the second completion revived interest in the dual completion in the early 1950's. Equipment and techniques were rapidly improved, and widespread acceptance of dual completions followed (Fig. 12). (13). The success and economic advantages experienced with dual completions since 1950 have resulted more recently in development of equipment and techniques for triple and quadruple completions. Multiple completion techniques have permitted production of many reservoirs which otherwise could not have been profitably developed.

Dual Completions

Many different combinations of tubing strings and packers for dual completions may be utilized, and all equipment required is now commercially available. Selection of a particular installation depends upon economics as influenced by many considerations including installation cost, artificial-lift requirements, corrosion, sand production, and workover requirements. To aid in selecting the optimum-type installation, discussion of dual completion equipment and techniques is given with specific comments on application of the various type installations. (14).

Single-Tubing, Single-Packer Dual

One of the oldest types of dual completions involves setting a production packer on tubing between reservoirs and producing the lower interval through the tubing and the upper interval through the tubing-casing annulus (Fig. 13). This type completion is still popular because of simplicity and low initial cost. It is applicable where the upper interval is a long-life flowing completion which does not present problems of sand production, severe corrosion, or abnormal pressure.

BEFORE EXAMINER UTZ
OIL CONSERVATION COMMISSION
EXHIBIT NO. ________
CASE NO. ________

It is common practice to install full-open packers and tubing equipment in order that through-tubing techniques may be utilized for workover of the lower interval. A wireline-operated circulating valve is usually placed above the packer for initiating flow from the upper zone through the tubing. The circulating valve is closed for normal production. Single tubing dual completions are commonly made with 5-1/2-inch casing and 2-inch tubing.

Workover of an upper zone requires use of a rig and removal of the tubing from the well. Concentric tubing can be used for low-pressure, squeeze-cementing of the lower zone or through-tubing dump bailers can be employed for plugback to avoid pulling tubing. Use of the tubing extension for workover of the lower zone is hazardous because the casing-tubing annulus must be used for circulation, exposing the upper zone to workover fluids and to squeeze pressures.

Single-Tubing, Two-Packer Dual

One of the main reasons for using two packers and only one tubing string in a dual installation is to achieve the flexibility of producing either zone selectively through the tubing. This type dual completion utilizes a packer between the reservoirs and a second packer with selective crossover flow equipment above the upper reservoir (Figs. 14A and 14B). Straight and crossover flow are distinguished by the flow paths of upper and lower zone production; lower zone production through the tubing is considered straight flow while upper zone production through the tubing is defined as crossover flow. The weaker zone, which may not flow through the casing-tubing annulus, can be diverted to the tubing, and production from the stronger zone can be taken through the annulus with this type installation. Similarly, if the pressure of one reservoir is abnormally high, production from this zone can be directed through the tubing with the lower-pressure reservoir being produced through the annulus.

Workover of the upper zone of a single-tubing, two-packer dual requires that the tubing and packers be removed from the well. The lower reservoir may be reworked by either the concentric tubing, dump bailer plugback, or wireline permanent completion method. Wireline workover of the lower zone can be performed by retrieving the straight or crossover flow choke by wireline and installing a tubing extension assembly of the required length (Fig. 14C). A concentric bypass assembly is installed below the extension hanger to seal the ports in the crossover flow assembly, thus isolating the interval between packers from the circulating system. With the exception of the bypass tool, wireline equipment and techniques for workover of the lower completion in this type dual well are the same as for reworking a single completion containing a packer.

Parallel-Tubing, Single-Packer Dual

Parallel-tubing strings are used in a single-packer dual installation primarily to permit independent artificial lift of both completions (Fig. 15A). A common dual completion of this type is two strings of

2-inch tubing installed independently in 7-inch casing. Wireline tubing extension of concentric tubing can be employed to wash sand from the upper zone, but both tubing strings must be removed for squeeze-cementing of this interval. Workover of the lower zone is accomplished in the same manner as previously described for the single-tubing, single-packer dual completion.

Parallel-Tubing, Two-Packer Dual

The basic reasons for utilizing two packers in a parallel-tubing dual completion are (1) to avoid exposing the casing annulus to sand-laden or corrosive well fluids or to abnormal pressures, (2) to provide a means of gas-lifting both zones from a common gas source in the annulus, and (3) to permit wireline workover of intervals below the lower packer without exposing upper intervals to circulating fluids and squeeze pressures (Fig. 15B). In addition, this type installation affords a means of independent artificial lift of both intervals by rod pumps or subsurface hydraulic pumps.

To squeeze-cement the upper zone of a parallel-tubing, two-packer dual completion, it is necessary that the tubing and packer be pulled from the well. However, a tubing extension can be utilized on the upper interval for washing sand or for placement of acids or other chemicals to stimulate the formation. The lower interval can be reworked with wireline permanent completion methods in a manner identical to a single completion containing a packer because the casing-tubing annulus is completely isolated from the upper reservoir. Similarly, other through-tubing workover methods can be employed as in a single completion.

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(Noted in text by underlined numbers).

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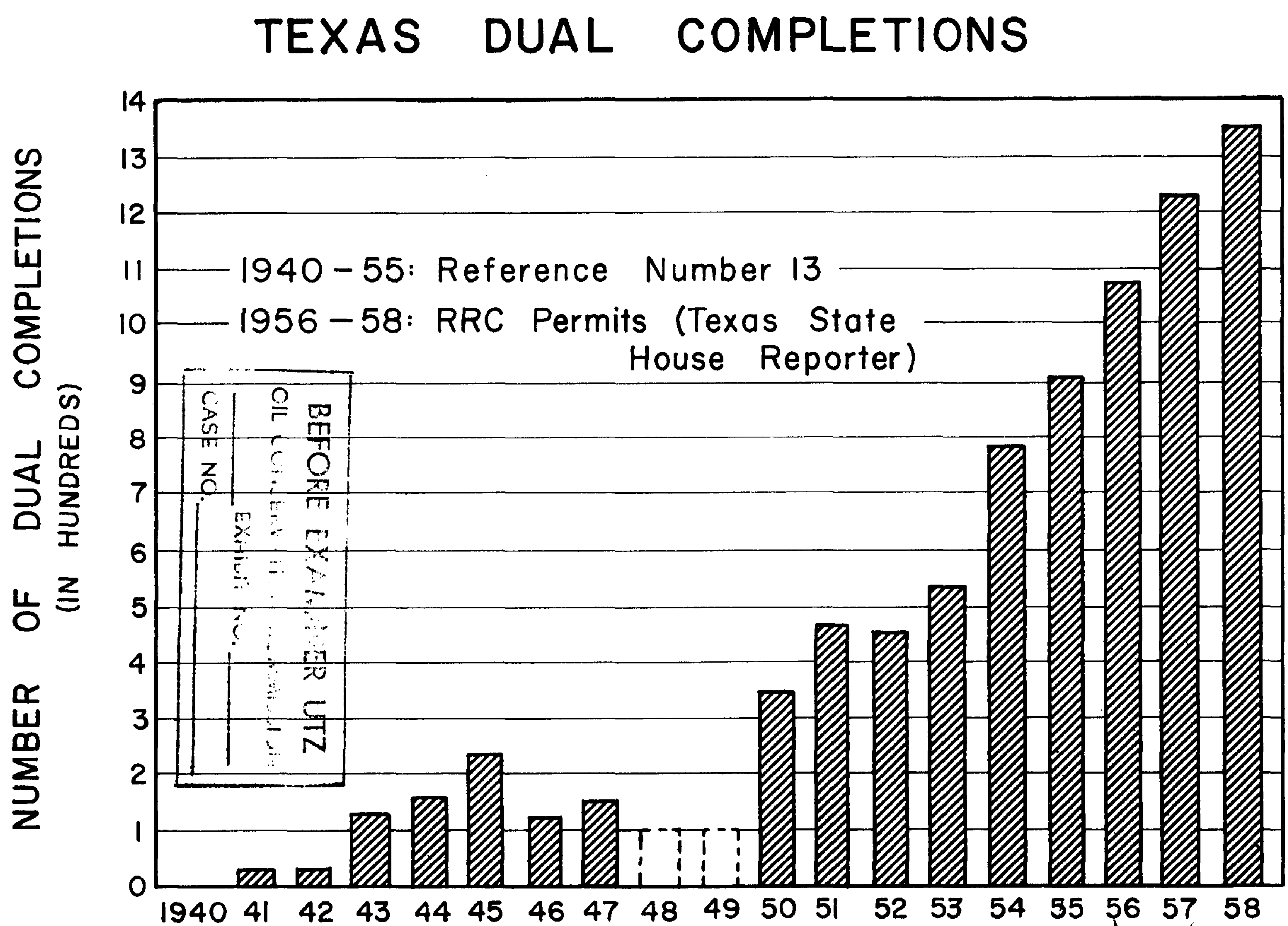
12. Alcorn, I. W., and Alexander, W. A.: "A Review of Multiple-Zone Well Completions", API 23rd Annual Meeting, Chicago, Illinois, November 10, 1942.

13. Prutzman, F. G.: "Economics Fosters Dual Completions", API Southwestern District Spring Meeting, Fort Worth, Texas, March 21-23, 1956.

14. Tausch, G. H., and Kenneday, John W.: "Permanent-Type Dual Completions", API Southern District Spring Meeting, San Antonio, Texas, March 7 - 9, 1956.



TEXAS DUAL COMPLETIONS
NUMBER OF DUAL COMPLETIONS
(IN HUNDREDS)
1940 – 55: Reference Number 13
1956 – 58: RRC Permits (Texas State House Reporter)
BEFORE EXAMINER UTZ
CASE NO.
0
1
2
3
4
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1940
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FIGURE 12

SINGLE TUBING SINGLE PACKER DUAL

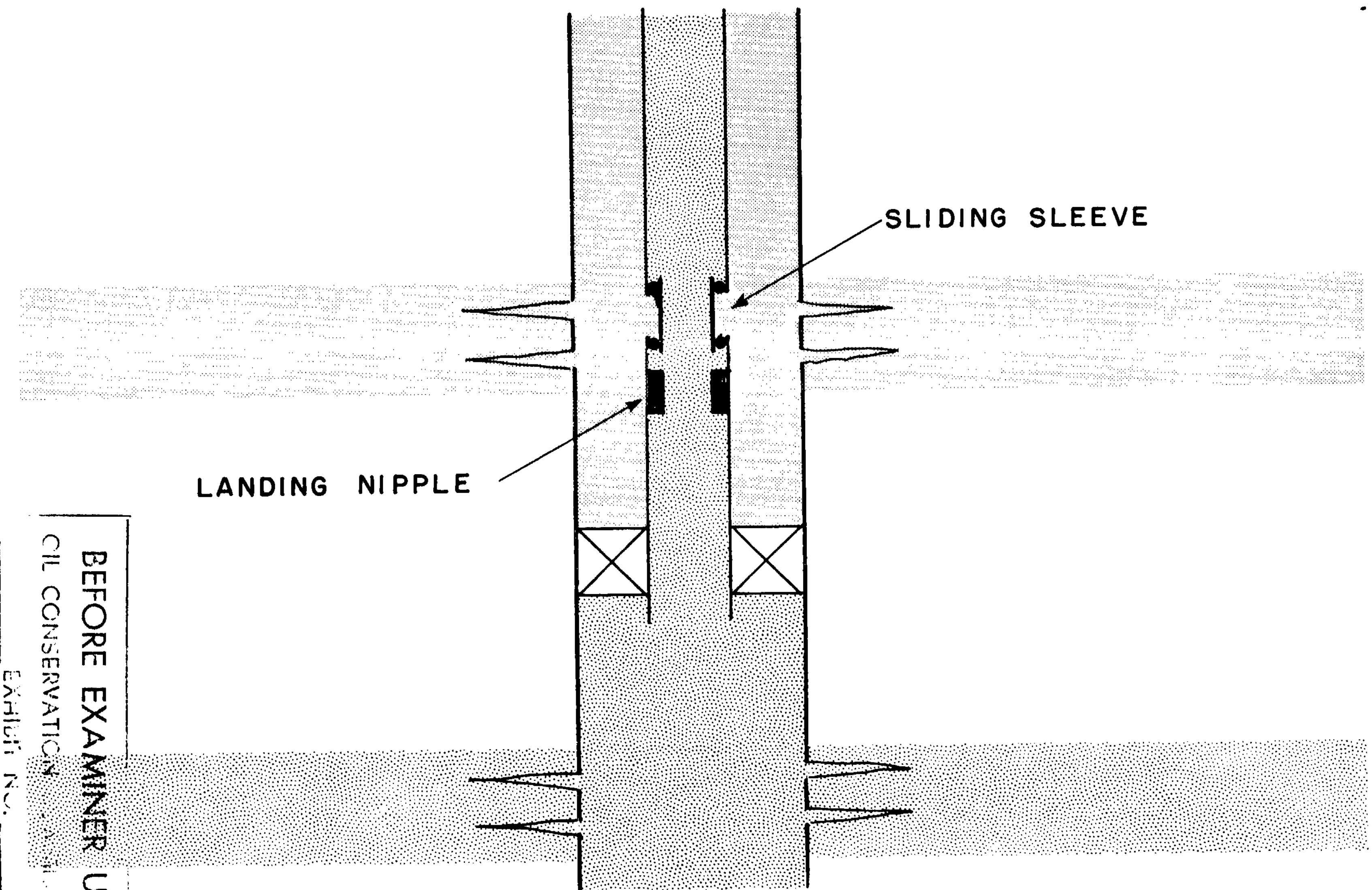


FIGURE 13

SINGLE TUBING TWO PACKER DUAL

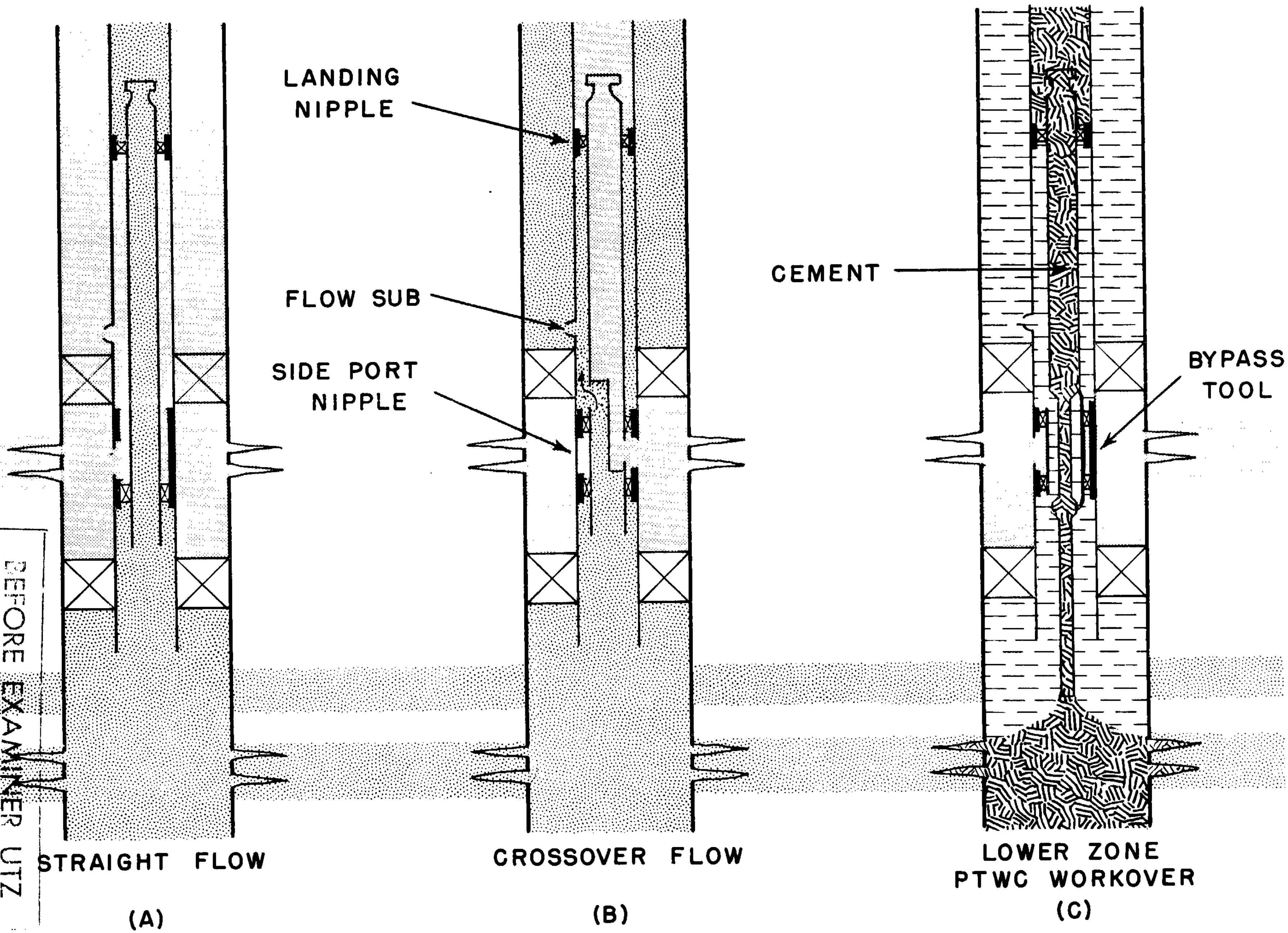


FIGURE 14

PARALLEL TUBING DUALS

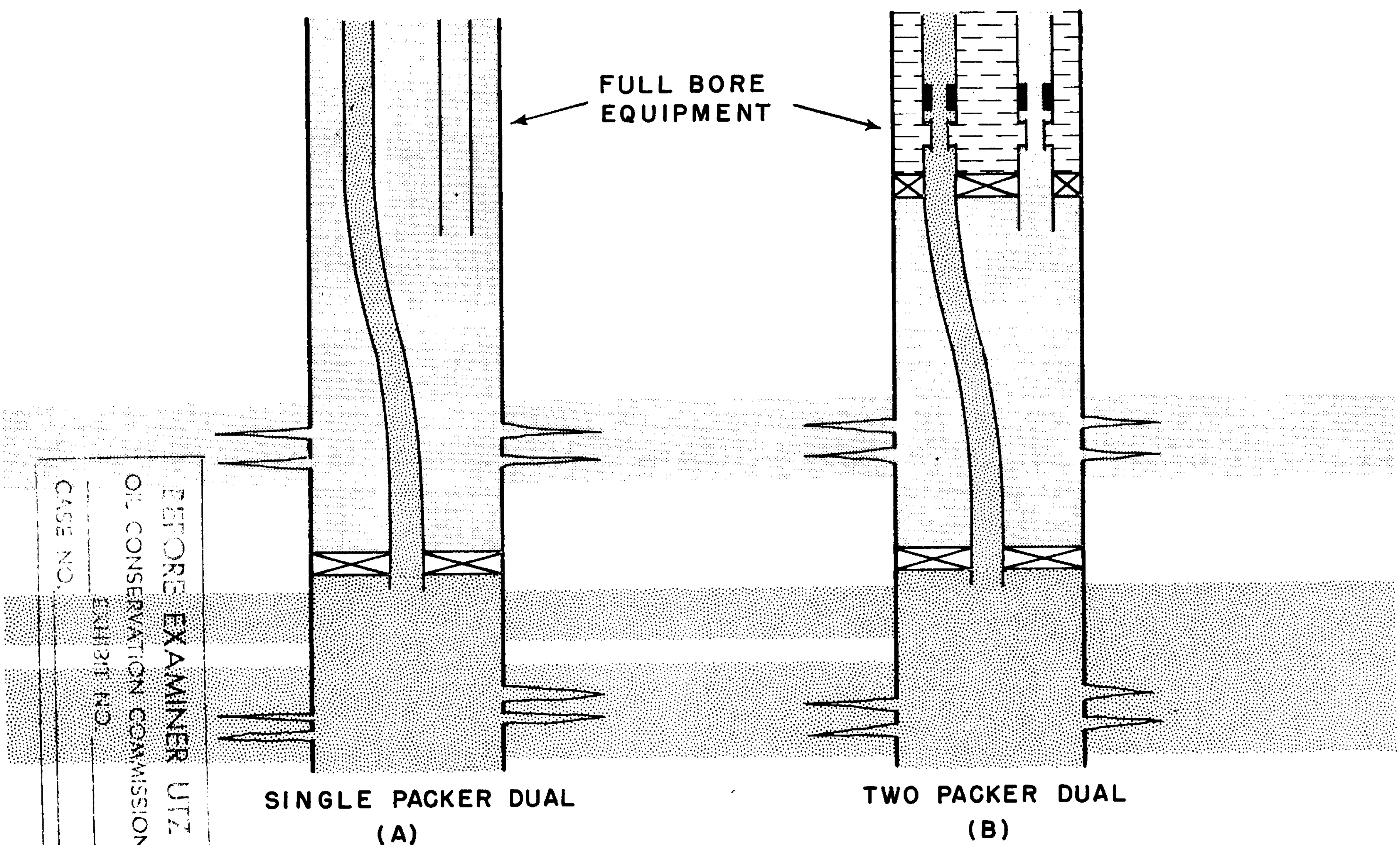


FIGURE 15

GAS CORROSION ANALYSIS

Caudill Wolfcamp (D. H. Crockett No. 2 Separator Gas 12-1-60)
(60° F. and 14.696 psia)

CO_2	-	1.1949%	
H_2S	-	0.0051%	3.25 grains/100 S.C.F.
Total Acid Gas	-	1.2000%	

Dunkle. 6
2146

Houston, Texas

December 8, 1960

Fluid Production Calculations
For Proposed Dual Completion
In New Mexico

Mr. R. A. McCarty
Midland, Texas

Attention: Mr. J. . Graybeal

This is to confirm our telephone conversations of November 28 and December 6, 1960, with Mr. J. . Willingham, regarding the fluid production from a proposed dual completion in New Mexico. Artificial lift calculations are summarized in the attached Table I and were made to determine the maximum fluid that could be produced in a well equipped with 5-1/2-inch casing and (1) a rod pump in 2-7/8-inch tubing, (2) a rod pump in 1-1/2-inch tubing, or, (3) subsurface hydraulic lift with 2-7/8-inch tubing and 1-1/4-inch concentric power oil string. As no gas vent is provided in this completion, the volumetric efficiency of the pumping equipment may be greatly reduced if the GOR of the produced fluid is greater than 50 cubic feet per barrel.

In regard to the question concerning efficiency of energy consumption in flowing one zone of the proposed well on a 2-7/8- x 5-1/2-inch annulus as compared to flow through 2-7/8-inch tubing, we offer the information shown in the attached Table II. The information submitted in the table uses flow in 2-7/8-inch tubing as a base and assumes such to be satisfactory. Numbers used in the lefthand column are from production data from an existing adjacent well using 2-7/8-inch tubing as the flow path. The gas requirement indicated in annular flow is that necessary to produce this same amount of fluid produced in tubing flow. Also shown is the maximum fluid production that could be expected from producing in the annulus if the same amount of gas used in the existing well were expended in annulus-type flow. The relationship between flow characteristics of 2-7/8-inch tubing as compared to the 2-7/8- x 5-1/2-inch annulus used in these calculations are indicated on the attached Figure 1. As far as we are able to ascertain, a study has not been made in the Industry to determine the optimum size tubing or annulus that would make maximum use of energy from a given amount of reservoir gas - that is to prevent slippage and gas breakthrough. However, field experience shows that production can be satisfactorily obtained by producing through the annulus.

If we can be of further aid, please advise.

ILLEGIBLE

T. A. Huber

By
R. S. Rugeley
Subsurface Engineering
Practices Section

RSR:ng
Attchs.
cc: Mr. Douglas Ragland, w/attch.

TABLE I

COMPARISON OF PUMPING METHODS IN A PROPOSED NEW MEXICO WELL

Method	Limiting Factor	Rod Size - In.	Plunger Size - In.	Length Of Stroke - In.	SPM	Unit Size Req'd.	Vol. Eff. (%)	Prod. B/D
Rod Pumping in 1-1/2-In. Tbg.								
From 10,650 ft.	Rod Stress	5/8, 1/2, Hi-Tensile	3/4	144	12	320-D	80	79.5
From 5,000 ft.	Rod Stress	5/8, 1/2, Hi-Tensile	1-1/4	144	12	320-D	80	210
Rod Pumping in 2-7/8-In. Tbg.								
From 10,650 ft.	Rod Stress	1, 7/8, 3/4 Std.	1-1/16	144	7	456-D	80	35.5
From 10,650 ft.	Rod Stress	1, 7/8, 3/4 Hi-Tensile	1-1/4	144	11	912-D	80	260
From 5,000 ft.		1, 7/8, Std.	2	144	12	640-D	80	602
Subsurface Hydraulic in 2-7/8-In. With 1-1/4 Power Oil Tbg.	Sur.Press. 5,000 psi	-	-	-	60		80	336

Note: **Tubing Anchored in All Cases.**
No gas vent provided - volumetric efficiency may be less.

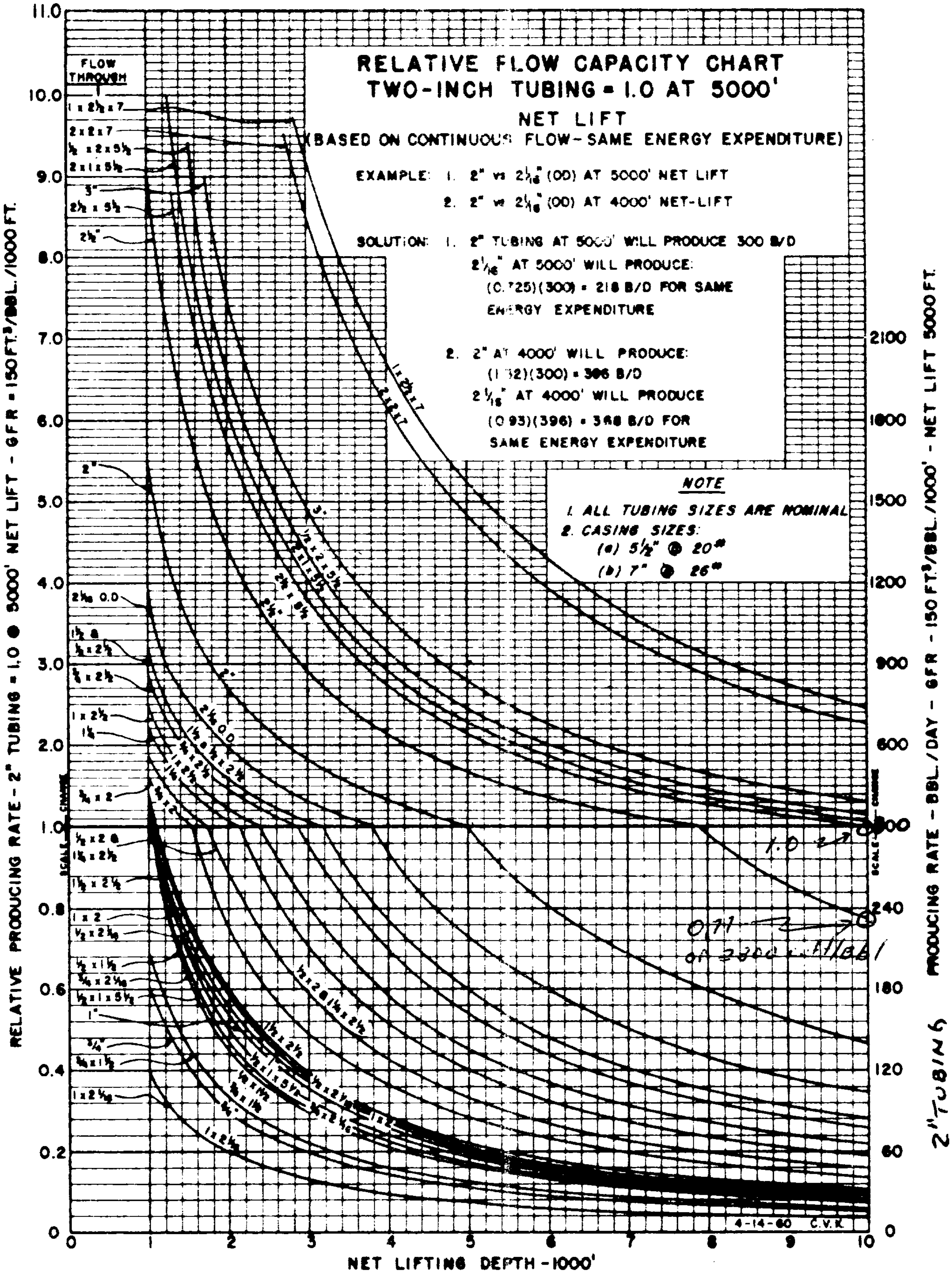
Petroleum Eng. Div.
Subsurface Eng. Pract. Section
RSR:ng 12-6-60

TABLE II

EFFECT OF FLOW PATH ON ENERGY CONSUMPTION
(2-7/8-In. Tubing vs. 2-1/2- x 5-1/2-In. Annulus)

	Existing Well	Proposed Well
Flow Path	2-7/8-In. Tbg.	2-7/8- x 5-1/2-Inch Annulus
Fluid Production	165 B/D	165 B/D
Water Content	6%	6%
Gas Rate Required	3,150 Cu.Ft./Bbl.	2,300 Cu.Ft./Bbl
Total Gas Per Day	520 MCFD	380 MCFD
With Energy Constant (3,150 Cu.Ft./Bbl) Production	165 B/D	215 B/D
Producing Depth	10,000 feet	10,000 feet

Petroleum Engineering Division
Subsurface Eng. Pract. Section
RSR:ng 12-8-60



$\dfrac{1.0}{0.77} \times 165\ B/D = 215\ B/D$

KONTOL®

PETROLITE CORPORATION

TRETOLITE COMPANY
DIVISIONS

corrosion inhibitors for petroleum producers

Saint Louis 19, Missouri
Brea, California

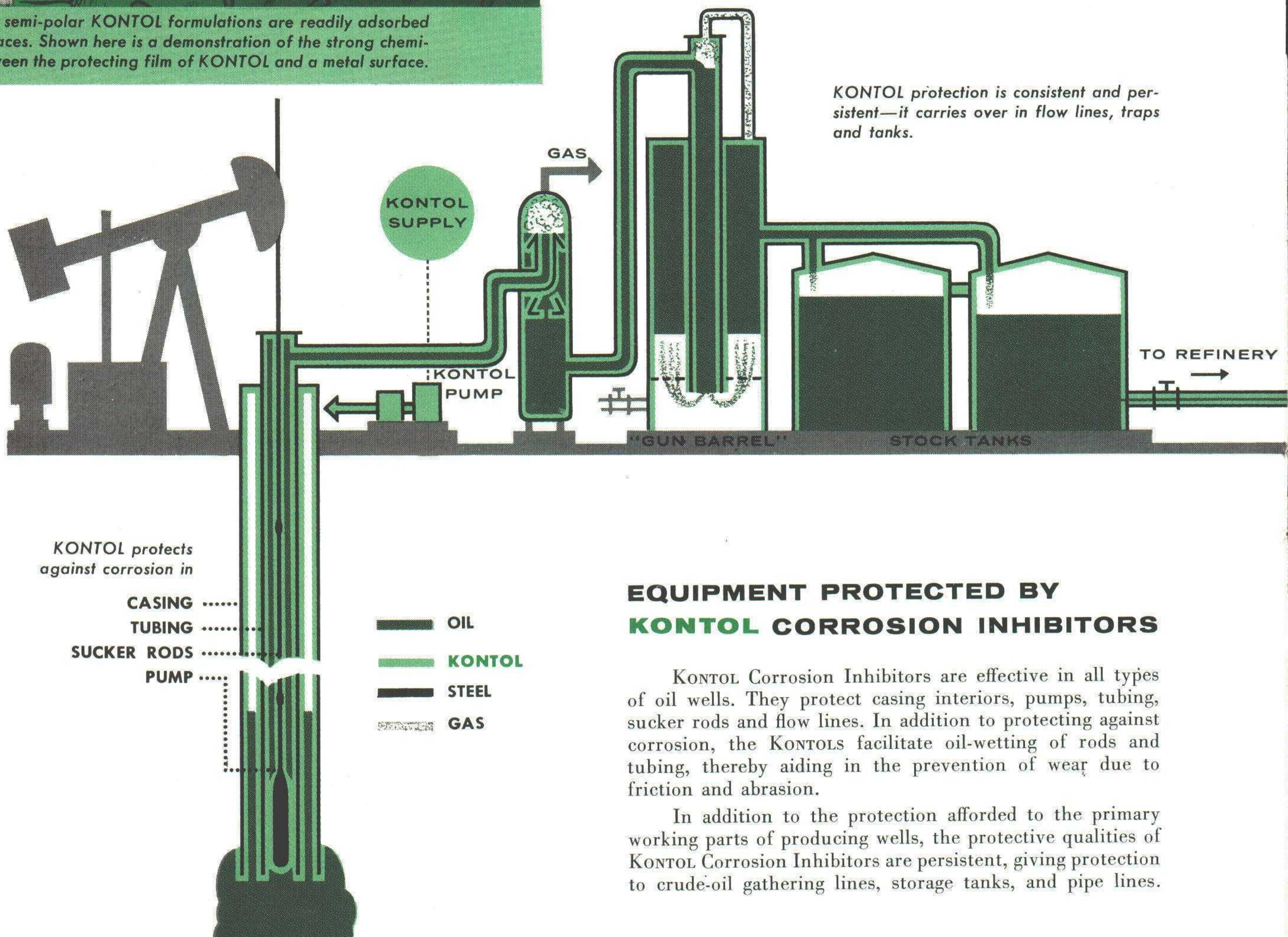
KONTOL* CORROSION INHIBITORS

KONTOL Corrosion Inhibitors are surface-active, high-molecular-weight organic compounds. The KONTOL inhibitors are specifically designed to inhibit corrosion of oil-, brine-, or gas-well equipment. They are available in a variety of formulas and forms—liquid, solid stick, pellet, and granules. Different formulas have different solubilities. KONTOL formulations are film-forming, semi-polar compounds which are readily adsorbed on metal surfaces.

Film-forming, semi-polar KONTOL formulations are readily adsorbed on metal surfaces. Shown here is a demonstration of the strong chemical bond between the protecting film of KONTOL and a metal surface.

HOW KONTOL CORROSION INHIBITORS PROTECT

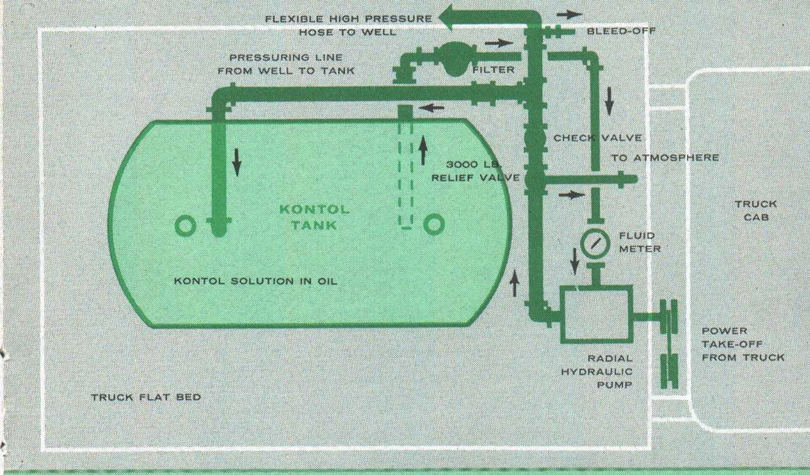
The KONTOL Corrosion Inhibitor film protects oil-well and gas-well production equipment from attack by corrosive elements in brine, crude oil, gas or combinations of these. The strong chemical bond between the protecting film of KONTOL inhibitor and the metal surface is demonstrated by the fact that, when application of KONTOL is stopped, a substantial period of time usually elapses before the corrosion rate returns to that observed before treatment began.

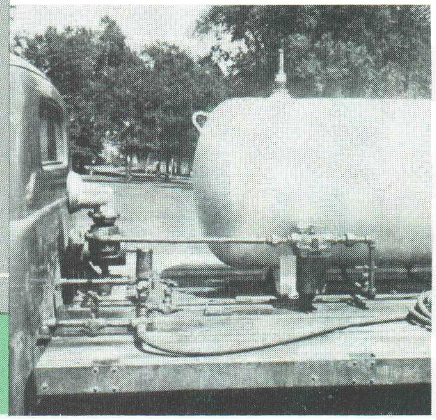


EQUIPMENT PROTECTED BY KONTOL CORROSION INHIBITORS

KONTOL Corrosion Inhibitors are effective in all types of oil wells. They protect casing interiors, pumps, tubing, sucker rods and flow lines. In addition to protecting against corrosion, the KONTOLS facilitate oil-wetting of rods and tubing, thereby aiding in the prevention of wear due to friction and abrasion.

In addition to the protection afforded to the primary working parts of producing wells, the protective qualities of KONTOL Corrosion Inhibitors are persistent, giving protection to crude-oil gathering lines, storage tanks, and pipe lines.





Detail of equipment arrangement of mobile KONTOL injection system, using truck flat bed.

PROCEDURE FOR THE TREATMENT OF WELLS WITH KONTOL

KONTOL inhibitors in liquid form are convenient to handle and apply. Where packed-off wells are encountered, or where unusual conditions in wells make the use of a liquid inhibitor impracticable, KONTOL sticks or pellets are effective and convenient forms for application of the inhibitor.

KONTOL CORROSION INHIBITORS IN LIQUID FORM

Liquid KONTOL is available with different solubility properties, as follows:

A. Oil-soluble, water-insoluble.

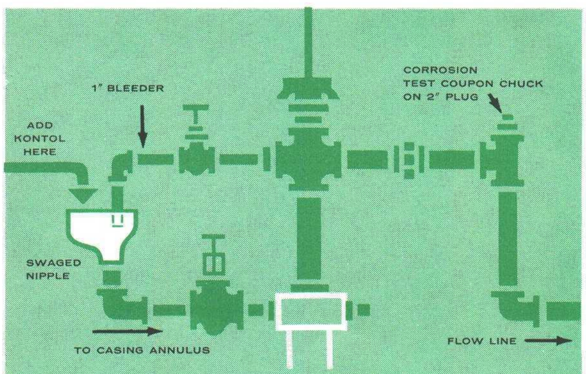
B. Oil-soluble, water-dispersible.

C. Water-soluble, oil-insoluble.

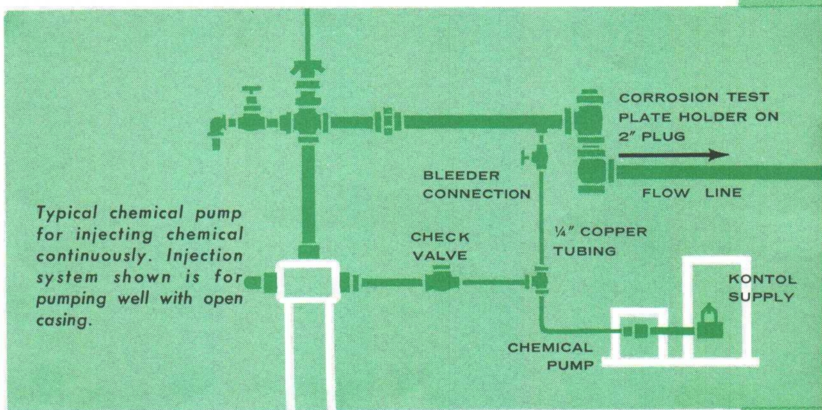
The KONTOL inhibitors, being surface-active organics, contain both hydrophobic and hydrophilic groups. In systems of oil and water, the greatest concentration of KONTOL molecules will be at liquid-liquid or liquid-solid interfaces with some molecules dissolved in both oil and water. The respective amounts of KONTOL dissolved by each phase are primarily dependent upon the pH of the system. Generally speaking, at lower pH, greater amounts of KONTOL become dissolved in the water phase; at higher pH, oil solubility increases.

The principal reason for having KONTOL available in formulas having different solubilities is to insure that the inhibitor can be directed to the desired location. For example, in high-fluid-level wells, where the casing annulus is filled with oil, water-soluble KONTOL will fall through the oil and reach the well bottom more rapidly than will an oil-soluble formula.

**Trademark Reg. U.S. Pat. Off.*



Typical well head connections for batch treating with liquid KONTOL.



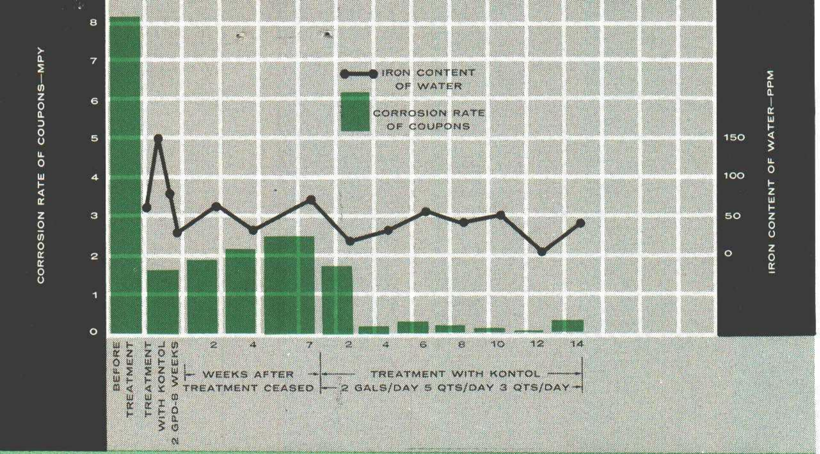
Typical chemical pump for injecting chemical continuously. Injection system shown is for pumping well with open casing.

INJECTION METHODS

Liquid KONTOL Corrosion Inhibitors may be injected into the corrosive system by a number of methods: (1) continuous pumping, using a chemical proportioning pump; (2) batch dumping; or (3) batch- or drip-lubrication. The injection method employed is usually determined by the nature of the system being treated. After protection has been established by initial use of heavier dosages, periodic applications of KONTOL are sometimes sufficient to maintain protection.

Where quantities smaller than one gallon are to be batch-dumped into the well annulus, it is recommended that the liquid KONTOL be diluted with several volumes of production fluids. Preferably, the production fluids are returned down the annulus for several minutes after the KONTOL has been dumped, to flush the inhibitor to bottom. Such flushing is recommended for use once a day where chemical proportioning pumps are employed. Alternatively, a bleeder line may be connected from well head to annulus, to allow a small stream of well fluids to flow continuously down the annulus.

Where gas wells are packed-off, treatment must be effected down the tubing. Use of KONTOL Corrosion Inhibitor sticks is recommended in such instances (see page 6), although it is sometimes desirable to employ the liquid KONTOL formulas. If the liquid KONTOLS are to be used, a sufficient volume of fluid must be provided to carry the inhibitor below the region of corrosivity in the tubing. Dilution of the liquid KONTOL with from 10 to 15 times its volume of distillate or other hydrocarbon is desirable. The well should then be shut-in for at least 15 to 30 minutes, to allow the inhibitor solution to fall.



A graphical case history report on results of KONTOL treatment in combating corrosion in high-pressure, gas-condensate wells.

LIQUID KONTOL TREATING PROCEDURE

Recommendations for the treatment of wells must take into consideration the severe conditions encountered in some areas. The quantities of KONTOL suggested in the following paragraphs will probably be excessive in most areas, and adequate protection will be afforded by use of appreciably less KONTOL than suggested in these outlined procedures.

A Flowing and pumping oil wells with open annulus

1. On the first day of treatment, inject 5 gallons of KONTOL Corrosion Inhibitor and, if possible, circulate the well down the annulus.
2. On the second and third days of treatment, inject from 3 to 5 gallons of KONTOL inhibitor daily. Do not circulate, but flush with 15 to 20 gallons of production fluids.
3. Subsequently, treat at a rate of 1 quart of KONTOL inhibitor for each 25 barrels of oil plus an additional 1 quart of KONTOL for each 300 barrels of water. Treat at this rate for a minimum of 2 months to establish protection and to evaluate effectiveness of the treatment.
4. Review the results of the Corrosion Rate Survey used to evaluate the effectiveness of treatment, and adjust the treating rate. Many corrosive pumping wells may be adequately protected with less KONTOL.

B Gas and condensate wells with open annulus

1. On the day treatment is initiated, inject 1 gallon of KONTOL inhibitor down the annulus for each million cubic feet (MMCF) of gas produced daily. A minimum of 5 gallons of KONTOL should be used. The KONTOL is preferably diluted with 3 to 4 volumes of oil, gasoline, or distillate before introduction into the well.
2. For the following week, use ½ gallon of KONTOL inhibitor for each MMCF of gas produced daily; but in no case less than 1 gallon of KONTOL daily.
3. Thereafter, the KONTOL injection rate may be reduced to 1 quart/MMCF, but not to less than 1 quart/day. Continue treatment at the reduced rate for two months.
4. Examine the experience record of the well or the results of Corrosion Rate Survey, and adjust the KONTOL injection rate accordingly.

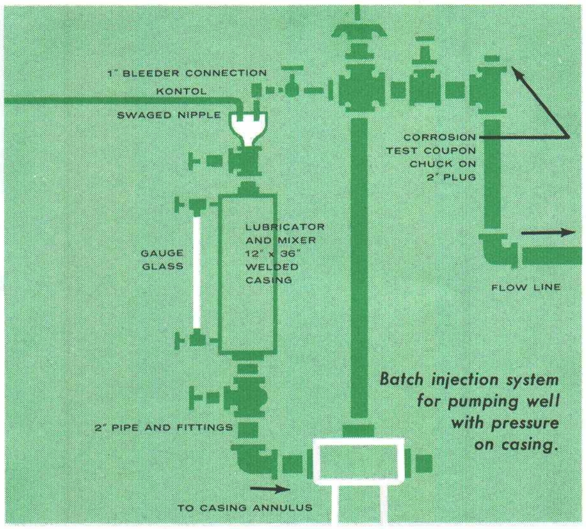
C Gas and condensate wells with plugged annulus

1. On the day treatment is started, inject 2 quarts of liquid KONTOL down the tubing of the shut-in well for each MMCF of gas produced daily. A minimum of 10 quarts of liquid KONTOL should be used.
2. For the next week, use 1 quart of liquid KONTOL for each MMCF of gas produced daily; in all cases use at least 4 quarts of KONTOL daily.
3. Subsequently, treat with 1 quart of liquid KONTOL for each MMCF of gas produced daily, never using less than 1 quart of liquid KONTOL daily. Continue treatment at this rate for 2 months.
4. Examine the experience record of the well, or Corrosion Rate Survey, and adjust the KONTOL injection rate and/or frequency of treatment accordingly.

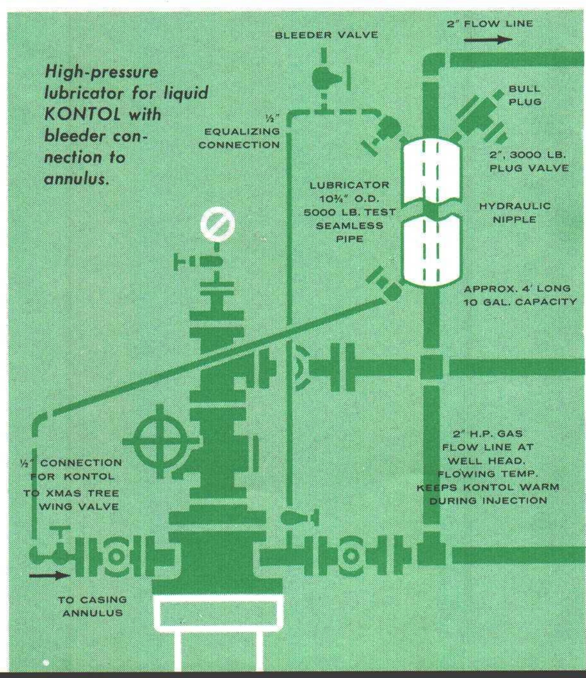
NOTE: See KONTOL STICK APPLICATION, page 6, for additional information on packed-off wells.

D Condensate wells with low-temperature extraction units

Condensate wells having a high well-head pressure are frequently equipped with low-temperature extraction units for the production of distillate and for dehydration purposes.



Batch injection system for pumping well with pressure on casing.



High-pressure lubricator for liquid KONTOL with bleeder connection to annulus.

In some such cases the initial use of large dosages of inhibitor may lead to unsatisfactory operation of the unit. This condition appears to result from the lowering of the interfacial tension between the distillate and the water. This in turn results in greater dispersion of water in the distillate and of distillate in the water when the mixture is severely agitated by flow through expansion chokes or valves. In some wells, the detergent action of Kontol may cause removal of scale and old corrosion products, which may stabilize dispersions of one liquid in the other.

When the well is equipped with a unit of this character, treatment may, for example, be conducted as follows:

1. Start treatment using 1 pint of liquid Kontol daily, dissolved in at least 3 volumes of oil or distillate, for each MMCF of gas. (If sticks are employed, use 1 Kontol stick for each 2 MMCF of gas daily.)

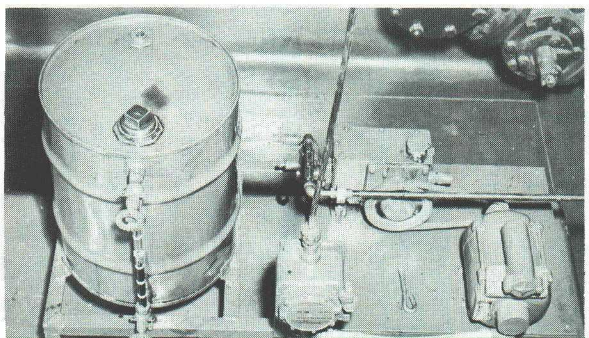
2. Continue treatment for a period sufficient to allow any cleaning of the well to be completed, and to determine the effectiveness of treatment.

3. Adjust the Kontol injection rate as dictated by the results obtained from the control procedure used.

NOTE: Special formulas of liquid Kontol (and of stick Kontol), having demulsifiers incorporated in them, are available for use in such wells when extremely unfavorable emulsification characteristics are encountered. Please refer also to page 6, Kontol Stick Application.

E *Water-flood and water-disposal systems*

Kontol Corrosion Inhibitors are also effective in water flood and water-disposal systems. Either water-soluble, or oil-soluble and water-dispersible formulas are normally used to insure dispersion of the Kontol in the water system.



Injection pump for using KONTOL in water-flood applications.

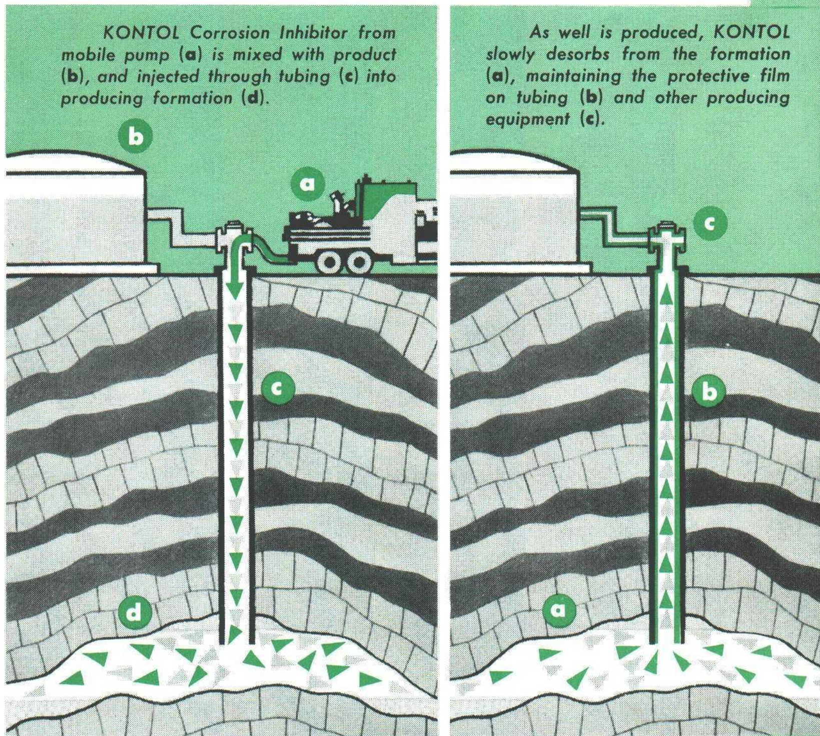
Kontol is most effective in non-aerated or anaerobic systems. All possible care should be exercised to prevent oxygen-contamination of the water. Oxygen scavengers, such as sodium sulfite or hydrazine, may be used in conjunction with Kontol inhibitors to assure optimum performance.

The recommended procedure for using Kontol in a water-flood or water-disposal system is as follows:

1. Inject Kontol inhibitor at the rate of 50 parts per million for the first 3 days, to assure complete coating of the entire system.

2. Subsequently treat at a rate of 20 ppm. Evaluate effectiveness of treatment by iron analyses, coupon studies, or electrical resistance probes.

3. Regulate the rate of Kontol Corrosion Inhibitor injection on the basis of the corrosion rate evaluation.



F *Squeeze method of application*

The success of this method appears to result from two important effects. After a satisfactory Kontol film is adsorbed on metal, only small concentrations of the inhibitor are required to maintain a protective Kontol film. In addition, by forcing Kontol into the producing formation, a reservoir of inhibitor is established in the pores and on the surfaces of the formation from which it is released by slow desorption. This releases a sufficient quantity of Kontol into the produced fluids to provide the low concentration required to maintain a protective film. Another advantage of the squeeze application is that it requires no attention between treatments.

To obtain best results with Kontol squeeze treatment two requirements are necessary. First, a good inhibitor film must be established over all the metallic surfaces. Second, there must be a continuous feed-back of inhibitor to repair desorbed areas. Therefore, it is necessary to inject an ample supply of inhibitor for subsequent distribution from the producing formation.

Both oil- and water-soluble Kontol inhibitors have been used in squeeze treating. However, oil-soluble Kontols are usually more effective.

The required frequency of squeeze jobs is largely dependent upon the amounts of well fluids produced. Treatments of gas condensate wells last for periods ranging from 6 months to more than one year. Wells producing fluids having a low water percentage require retreatment after periods of from 6 to 9 months. Wells which produce large quantities of water may require retreatment after 3 or 4 months.

A typical squeeze treatment with oil-soluble Kontol is carried on as follows:

1. Dissolve 55 gallons of Kontol in 100 gallons of light hydrocarbon, such as kerosine or diesel fuel, and spot the mixture at the face of the producing formation.

2. Inject enough crude oil or other fluid hydrocarbon to fill the tubing and pumping lines.

(Squeeze application)

3. Inject 40 to 50 barrels of oil or hydrocarbon as overflush. Care should be taken to inject this slowly, so that the producing formation is *not* fractured or fissured. For most formations, the injection rate should not exceed 3 or 4 barrels per minute.

Evaluation of the effectiveness of inhibitor squeeze applications in some instances may be difficult. The installation of test coupons for short periods of time is of little value, because, while there may be enough inhibitor present in well fluids (following squeezing) to maintain an established film, usually there is not sufficient inhibitor present to protect an uncoated, freshly sand-blasted, highly-reactive metallic coupon surface.

In sweet-oil and gas condensate wells, iron analysis comparisons before and following squeezing usually give a good indication of protection. These analyses will also indicate when the treatment should be repeated.

In sour wells, most of the iron corrosion products are present as insoluble iron sulfide, and representative sampling is usually difficult. In such instances, use of an electrical resistance probe for the measurement of corrosion rate is usually satisfactory.

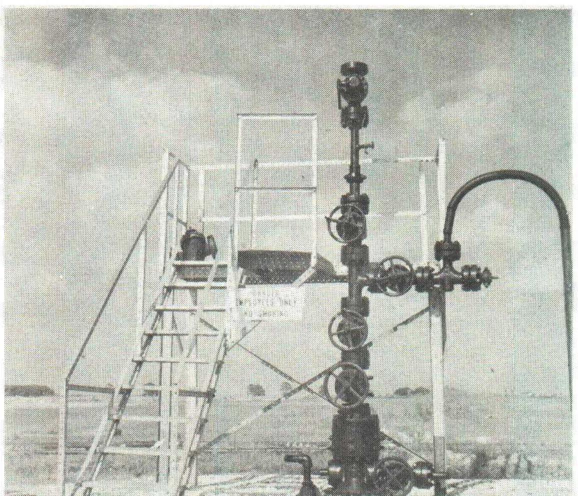
Electrical resistance probes may be installed as a semi-permanent installation, or may be lubricated through a valve with proper retrievers. Care should be exercised to select the proper probe so that it will have sufficient life in its corrosive environment.

The probe should be located so that it will be contacted by the inhibitor as the well is squeezed. Periodic reading of corrosion rate may subsequently be made, to follow the effectiveness of treatment and to establish the required frequency of squeeze treatment.

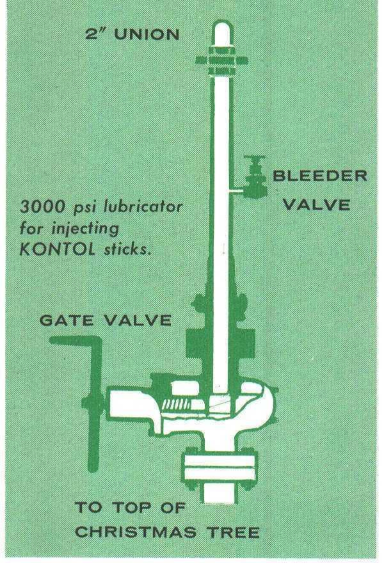
KONTOL STICK APPLICATION

KONTOL Corrosion Inhibitors in solid stick form are recommended for use in producing wells wherein the annular space is packed-off.

KONTOL sticks are 1½″ in diameter by 18″ in length. They are both weighted (specific gravity 2.0) and unweighted (specific gravity 1.0), and range in melting point from 145° F. to 250° F. One KONTOL stick is equivalent in treating effectiveness to one quart of liquid KONTOL.



Lubricator on Christmas tree for injection of KONTOL sticks.



The general procedure for KONTOL stick treatment is as follows:

A Flowing oil well with plugged annulus

1. *Initial Treatment*—Drop 10 weighted KONTOL sticks down the tubing of the shut-in well. Allow the well to remain shut-in long enough to permit the sticks to reach the well bottom and melt.
2. *Subsequent Treatment*—Drop one weighted stick for each 25 barrels of oil produced, plus an additional stick for each 300 barrels of water produced. Continue this treatment for a minimum period of two months to establish protection and to evaluate the results.
3. Examine the experience record of the KONTOL-protected well and the results of Corrosion Rate Surveys. Adjust the KONTOL stick treatment accordingly.

B Gas and gas condensate well with plugged annulus

1. *Initial Treatment*—Drop 2 KONTOL sticks down the tubing of the shut-in well for each MMCF of gas produced daily. A minimum of 10 KONTOL sticks should be used.
2. For the following seven days use one KONTOL stick for each MMCF of gas produced daily.
3. Subsequently treat with one KONTOL stick for each MMCF of gas produced daily; but, in all cases, a minimum of one KONTOL stick is recommended. Continue this treatment for 2 months.
4. Examine the well's experience record and Corrosion Rate Surveys. Adjust the treatment accordingly.

KONTOL CORROSION INHIBITOR PELLETS

KONTOL pellets provide a convenient method for handling and applying the corrosion inhibitor. Being non-liquid and easily packaged, KONTOL inhibitor pellets are easily transported from well to well. They are applied by dropping down the well annulus.

KONTOL Corrosion Inhibitor pellets are easy to use in any well with an open annulus. They drop through the well fluids by their own weight and do not require flushing. The pellets are cylindrical in shape and are available in 2 sizes; one, ⅝″ in diameter by ⅝″ thick; the other $13/16$″ in diameter by ⅝″ thick. With either size pellet, two pounds are equal in protective effectiveness to one quart of liquid KONTOL.

KONTOL IN GRANULAR FORM

KONTOL Corrosion Inhibitor granules are recommended for producing wells wherein the annular space between the casing head and tubing will not permit passage of the KONTOL solid pellet.

One-half pound of KONTOL granules is equivalent in effectiveness to approximately one quart of liquid KONTOL Corrosion Inhibitor, or two pounds of KONTOL pellets.

EVALUATION OF CORROSION RATE

A number of methods are in use to evaluate corrosion rate of internal surfaces of oil field equipment. Many of these are indirect evaluations; hence, each will be discussed independently.

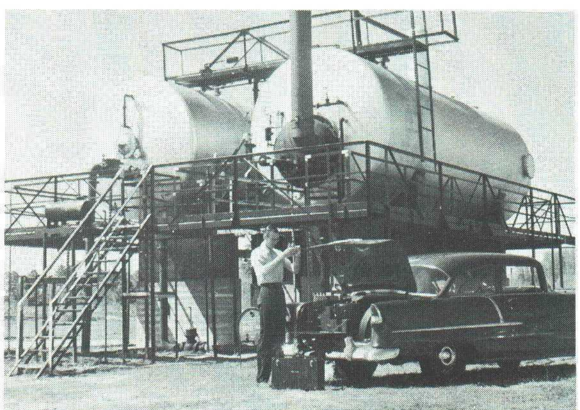
A *Iron analyses*

If iron or steel is in contact with corrosive oil and/or water it is possible to analyze these fluids for iron corrosion products. Two factors influence the validity of this method of evaluation: First, all of the iron present must be a result of corrosion; and, second, it must be possible to obtain a representative sample.

Many oil field waters naturally contain some dissolved iron. It is frequently impossible to differentiate between formation iron and iron in corrosion products.

Iron analyses of fluids are useful, however, where iron contents during KONTOL treatment can be compared with iron contents prior to treatment.

In sour systems, most of the iron is usually present as insoluble iron sulfide particles. It is often difficult to obtain representative samples of produced fluids because chunks of iron sulfide peel off periodically, although not uniformly, and the samples for this reason may not contain truly representative amounts of iron corrosion products.



Tretolite Service Engineer tests for iron content in the field.

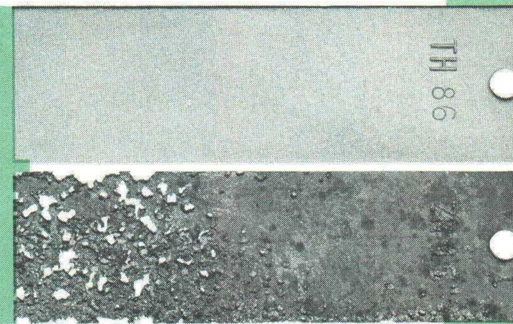
B *Weighed test coupons*

Another method of evaluating corrosion rate is by means of weighed metal test specimens (coupons) installed in the flow lines of producing oil-, water-, or gas-wells. Tretolite Company coupons are of 1020 mild steel, and are sandblasted and weighed to the nearest one-tenth milligram prior to exposure.

These coupons are usually left in flow lines for a minimum period of 14 days. Following exposure they are carefully cleaned, reweighed and corrosion rate determined in M.P.Y. (mils penetration per year).

Weighed test coupons are one way to evaluate corrosion rate. Sandblasted coupon (top photo) is introduced into flow line.

After minimum of 14 days it is removed (bottom), cleaned and reweighed to determine M.P.Y. (mils penetration per year).



It should be remembered that coupons indicate the corrosion rate only at the point of exposure, and the corrosion rate may be quite different deep within the well. Coupons exposed for only short time periods may not reflect a similar corrosion rate when compared with coupons exposed over long periods of time.

It is also possible that coupons inserted at the well head may become coated with scale or paraffin and hence not indicate the true corrosion rate in other areas where these accumulations do not occur.

In many instances, however, coupon comparisons of corrosion rate before and after KONTOL Corrosion Inhibitor treatment are valuable aids in the evaluation of KONTOL effectiveness and in establishing the proper dosage.

C *Electrical resistance probes*

Installation of an electrical resistance probe in the flow line allows the progress of corrosion of the probe to be measured electrically by means of a metering instrument. The probe may be constructed of a wire, strip, or tube of any desired metal or alloy.

The operation of the probe with its measuring instrument is based on the principle that the electrical resistance of a metal specimen is related to its cross-sectional area. Thus, as the probe element is corroded by its environment, its electrical resistance changes; and measurements of this resistance can be related to corrosion rate. These probes are constructed with a coated non-corrodable reference specimen, the resistance of which is compared with that of the corroded specimen to yield temperature-independent values.

Where probes are used, care should be exercised to select the proper probe to withstand flow conditions and to have sufficient life in its corrosive environment.

The advantage of the probe is that readings of corrosion rate can be made without removal of the specimen, and subsequent progressive readings may also be made. It should be remembered, however, that the probe is similar to a coupon in that it measures only the degree of corrosion activity at its location.

D Pony rods and tubing subs

Another method of surveying corrosion rate involves the use of short sections of rods (pony rods) or short sections of tubing (subs) which are sandblasted and weighed. These may be placed at any desired location in the rod or tubing string. They are normally left in the well for approximately 3 months, after which they are removed, cleaned and weighed to determine the amount of metal lost.

While pony rods or tubing subs give an accurate evaluation of corrosion rate at any desired location in the string, they are costly to install and remove, and the time between examinations is long.

E Caliper surveys

Another method used for determining corrosion rate of internal surfaces of tubing is through the use of the tubing caliper.

This tool is lowered by means of a wire line to the bottom of the well. As the tool is retrieved, actuated feelers follow the surface of the tubing, reveal any irregularity and literally feel for corroded areas and indications of pitting. A stylus records all such irregularities as a permanent record as the tool moves up through the tubing.

This method has the advantage of inspection without removal of tubing from the well. It is somewhat expensive, however, and cannot be used if there are any obstructions in the tubing string.

REPLACEMENT RECORDS

The methods of corrosion rate evaluation described above indicate various means by which the degree of protection derived from the use of corrosion inhibitors can be determined. The keeping of accurate and detailed records of parts requiring replacement because of corrosion damage provides another valuable method of determining the degree of protection.

Such replacement records will, over a period of time, often show the development of a pattern of failure. By following such data, it usually is a simple matter to make changes in the system and, by so doing, improve protection.

In any program of corrosion mitigation the keeping of accurate replacement records will prove extremely valuable.

CORROSION RATE SURVEY

The Tretolite Company offers a corrosion rate survey service to any producer who is interested in determining the rate of corrosion before, or during, treatment. In general, the testing of every well in a field is not necessary, since corrosion rates are usually very similar in adjacent wells. It is, therefore, suggested that 2 or 3 representative wells from each lease or field be chosen for testing.

When this corrosion rate survey service is requested, the Tretolite Company will:

1. Supply weighed steel test coupons for insertion in the flow stream at the well head or flow line.
2. Evaluate and report the results of the tests with coupons.
3. Analyze well brine for iron, dissolved salts, chlorides, and pH.

For information on the best methods for surveying the corrosion on your lease, call the Tretolite Field Engineer in your production area, or write or call the nearest Tretolite Company office.

ADVANTAGES OF KONTOL CORROSION INHIBITORS

Dependability KONTOL Corrosion Inhibitors are effective in all types of internal corrosion problems. Their use has enabled oil producers to prevent many costly losses.

Economy KONTOL Corrosion Inhibitors protect both carbon and alloy steels. The protection provided by KONTOL often permits the use of carbon steel instead of more costly alloys. Even when plastic or cement-coated pipe is used, the use of KONTOL protects against coating failures. The cost of KONTOL protection is nominal in comparison to the cost of steel and other expenses which would be incurred through corrosion-caused failures in the absence of protection.

Flexibility KONTOL protects against all classes of corrosive attack. The usual corrosion caused by brines, sour crudes, etc., is prevented, as are also hydrogen embrittlement and hydrogen blistering. KONTOL Corrosion Inhibitors are available in water-soluble, oil-soluble-and-water-dispersible, and oil-soluble-and-water-insoluble formulations. They are effective in pumping, flowing, gas, gas-condensate, water-flood, and water-disposal systems.

Ease of Application KONTOL Corrosion Inhibitors are available in liquid, stick, pellet, and granular forms. They are easily applied by pumping, dumping, or lubricating in the liquid form, or by simply dropping the sticks, pellets or granules down the well.

Safety KONTOL is safe to handle, store and apply. It is non-poisonous, non-explosive, and non-flammable under all normal conditions. No goggles, masks, aprons, gloves, or similar protective equipment are required for handling.

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