Field Evaluation Of Extended Period Batch Treating With Corrosion Inhibitors

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INTRODUCTION

The use of chemical inhibitors to retard corrosion of tubular goods and sucker rod strings in wells producing fluids of a corrosive nature has long been accepted by the oil industry. In Central Kansas our company is using chemical inhibitors for corrosion control in all wells producing fluids with a corrosive tendency.

Before initiating "Extended Period Batch Treatment," (EPBT) treating of these corrosive environment wells was accomplished by frequent administration of chemical inhibitors down the annulus followed by a volume of the well's produced fluid to flush the inhibitor to the wellbore fluids. The frequency of treatment was originally once per day. As experience was gained on the use of inhibitors, the frequency was diminished until the average well was receiving a weekly treatment -- that is, once each week the well received a batch treatment of inhibitor. The volume of inhibitor used in this treatment was based upon 12.5 ppm of the total fluid produced between treatments. The treating rate of 12.5 ppm of total fluid has been determined to be the optimum treating rate for corrosive wells in Central Kansas.

Corrosion coupons were utilized to check the effectiveness of the inhibitor treatment program. During the transitional period between daily treatment, semi-weekly, and weekly treatments, it was observed by means of coupon tests that the desired corrosion control had not been sacrificed.

This led to experimentation EPBT, an inhibitor-treating process in which a calculated extended-period's required volume of inhibitor is dumped down the annulus of the well, thereby forming an inhibitor-oil mixture of high inhibitor concentration in the annular fluids. This inhibitor-oil mixture is either circulated through the tubing string and returned to the annulus, or part of this inhibitor-oil mixture is displaced through the tubing string to deposit a protective film on the exposed metallic surfaces. The returned-circulated or the undisplaced inhibitor-oil mixture then serves as a reservoir of inhibitor protection to repair any damaged film for the extended period of treatment.

Testing with EPBT has been confined to the Geneseo-Edwards Field in Central Kansas. The main producing horizon in the field is the Arbuckle dolomite. Fluid production consists of oil and water which is impregnated with hydrogen sulfide (H_2S) which is very corrosive to all downhole metallic equipment. For this reason, corrosion inhibitors have been used in this field since the early 1940's when the field started to produce sizable quantities of water.

Under these conditions, an EPBT investigation was made in an attempt to answer the following questions:

1. How long can a well operate with good corrosion protection between treatments?
2. What effect do well-producing characteristics such as productivity and fluid level have on successful treatment?
3. Is the brand of inhibitor important to successful treatment?
4. Is complete circulation of chemical inhibitors necessary for proper protection?

INITIAL TESTS

In November 1959, EPBT began with 2 Arbuckle wells which were selected for they were believed to be representative of the average Arbuckle-producing well in Central Kansas, and both had been coupon test wells with a backlog of representative coupon data. Both wells were batch-treated with a 1 month supply of inhibitor. The inhibitor was dumped down the annulus, circulated through the tubing string, and returned to the annulus in both wells. One of the test wells was not retreated for 6 weeks while the other well was produced for 2 months before retreating.

Corrosion coupons were installed at the wellhead to check the effectiveness of the treatment. Two sets of coupons were used so that the overall corrosion rate for the extended period could be measured as well as the incremental film repair protection obtained throughout the experiments. The coupon used to measure the overall corrosion rate for the life of the experiment was installed prior to circulating the wells. It therefore received the basic protective film that the rods and tubing received during the circulation of the inhibitor. Coupons measuring the incremental rates were installed after the circulation period. Therefore, they measured the feedback protection of the inhibitor from the annulus. These coupons were changed approximately every two weeks so that the corrosion rate could be checked during the progress of the experiment. The results obtained from these two initial test wells are listed in Table 1.

TABLE I

Test Well	Coupon Exposure Period	Coupon Measured Corrosion Rate MPY	Remarks
A.W. Shonyo	11/18/59 - 12/31/59	1.1	3rd Period, 2 Wks.
No. 6	11/18/59 - 12/2/59	0.6	1st Period, 2 Wks.
	12/2/59 - 12/16/59	2.9	2nd Period, 2 Wks.
	12/16/59 - 12/31/59	1.9	3rd Period, 2 Wks.
H.W. Moll-	11/18/59 - 1/14/60	0.1	Overall Rate
hagen No. 1	11/18/59 - 12/2/59	0.3	1st Period, 2 Wks.
	12/2/59 - 12/16/59	0.6	2nd Period, 2 Wks.
	12/16/59 - 1/14/60	0.2	3rd Period, 4 Wks.

The results observed from these initial tests appeared to be favorable when compared with the corrosion history as obtained from the coupon tests during the pre-EPBT period. A plot of the corrosion rates for these two wells may be found in Figures 1 and 2.

EXPANSION OF TEST PROGRAM

The two initial test wells were retreated with a 2 month supply of inhibitor and testing was continued. These 2 wells, as previously stated, were representative of average Arbuckle wells in Central Kansas, but testing of wells approaching the extremes in producing characteristics and fluid levels was desired for complete analyses of the program.

Thirteen other Arbuckle wells throughout the Geneseo-Edwards Field were selected for EPBT tests in order that more information could be obtained on the requirements for successful EPBT. These wells were selected on the following basis:

1. Large volume producers (in excess of 500 BTFPD) High fluid level (in excess of 1000 ft of pump submergence)
2. Low volume producers (less than 150 BTFPD) Low fluid level (less than 100 ft of pump submergence)
3. Average producers (150-500 BTFPD) Average fluid level (100-1000 ft of pump submergence)

These selected wells were subdivided into 3 groups so that the 3 brands of chemical inhibitor used in Central Kansas by Continental could be evaluated. Each of the chemicals is oil-soluble, water-dispersable liquid amine inhibitors. The test program has proved all tested chemicals to be equally successful in retarding corrosion of downhole equipment with EPBT.

The size of the treatments was varied, with some wells receiving up to a 3 month supply of inhibitor. The length of the tests was also varied, with several tests lasting as long as 7 months and 3 tests lasting 9-1/2 months. In 3 of the test wells, the annular fluids were completely displaced before treatment to remove any inhibitor concentration that remained as a result of previous treatments. All 15 test wells, their producing characteristics, and general results of the EPBT tests may be found on Table II, "Extended Period Batch Treating Test Data."

RESULTS OF THE TESTS

In all but 4 of the extended treatments, the overall corrosion rate was less than 1.0 mpy. In 1 test on the A. W. Shonyo No. 6 (Figure 1), the rate was 1.1 mpy which is not a critical corrosion rate considering the coupon holder for this particular testing period was non-insulated. This well required servicing during another test period. During servicing, the coupons were exposed to oxygen which can account for the corrosion rate of 1.2 mpy. The same situation occurred on the A. H. Meyer No. 8 (Figure 3) which recorded a corrosion rate of 1.38 mpy for one test. A test on the P. Nickel No. 9 (Figure 4) had a corrosion rate of 1.46 mpy. This well was treated with a 1-1/2 month supply of inhibitor and tested for 9-1/2 months. This test indicated that effective corrosion protection cannot be maintained for 9-1/2 months with a 1-1/2 month supply of inhibitor.

The incremental corrosion rates varied considerably throughout the extended period. A number of reasons can be responsible for the fluctuation of the rates; however, since the corrosion rates did not rise progressively, it is an indication that inhibitor was being fed through in intervals allowing film repair protection throughout the extended period.

In comparing the results of EPBT with the conventional method of daily or weekly treatment, it is observed that (according to coupon data) more overall protection is obtained with the extended batch treatment. During the conventional daily treatment periods, the corrosion rates were unstable and varied from adequate protection of less than 1.0 mpy to as high as 12.5 mpy during the interval shown on the curves and as high as 18.4 mpy during earlier periods. The overall corrosion rates during the EPBT were lower and much more desirable.

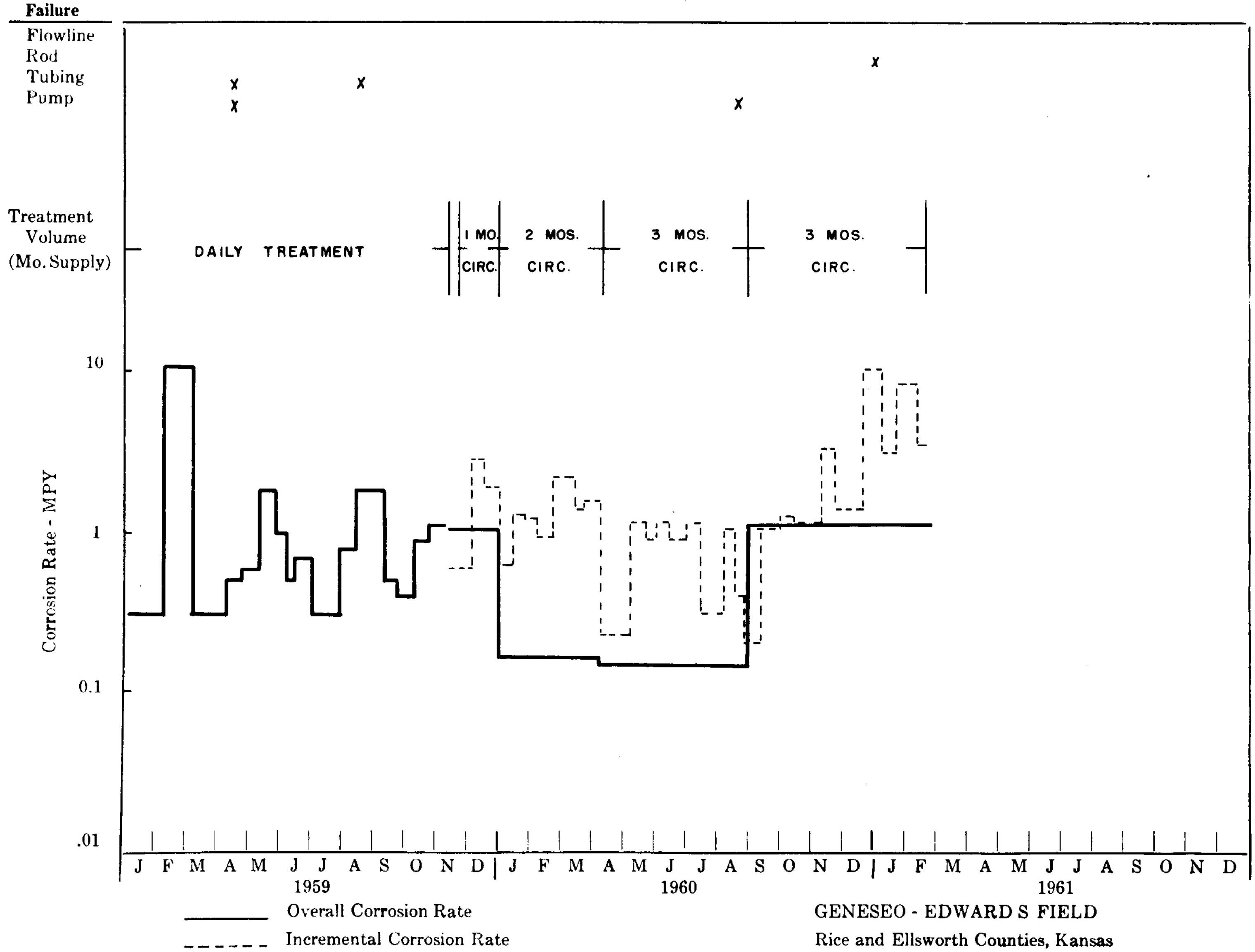
As previously mentioned, 3 tests were conducted for 9-1/2 months and several other tests were conducted for periods as long as 7 months. During the 7 month tests, the overall corrosion rate remained within the desired range of less than 1.0 mpy. The tests indicate that adequate protection can be obtained for 7 months from a 3 month supply of inhibitor. The 3 treatments in which the annular volume had been displaced prior to the EPBT were as successful as the other treatments (See Table II). This indicates that the success of the treatments was not due to chemical carryover from previous treating methods.

In the initial experiments, it was believed that circulation of the inhibitor-oil mixture through the tubing and back down the annulus was a necessity for successful treatment. This circulation procedure is a time-consuming problem on wells with high fluid levels. Several of the test wells were flushed with 1/2 to 7 bbl of fluid in lieu of circulation. The volume of flush was dependent upon the amount of fluid in the annulus. In comparing the results of these flush treatments with circulated treatments, it is observed that the corrosion rates are as favorable as those obtained with circulation. It is therefore believed that complete circulation is not a requirement for successful EPBT.

One well, the A. W. Shonyo No. 6, was tested with coupon pony rods to determine the corrosion rates at 3 points in the rod string. These pony rods were spaced directly above the pump plunger, in the

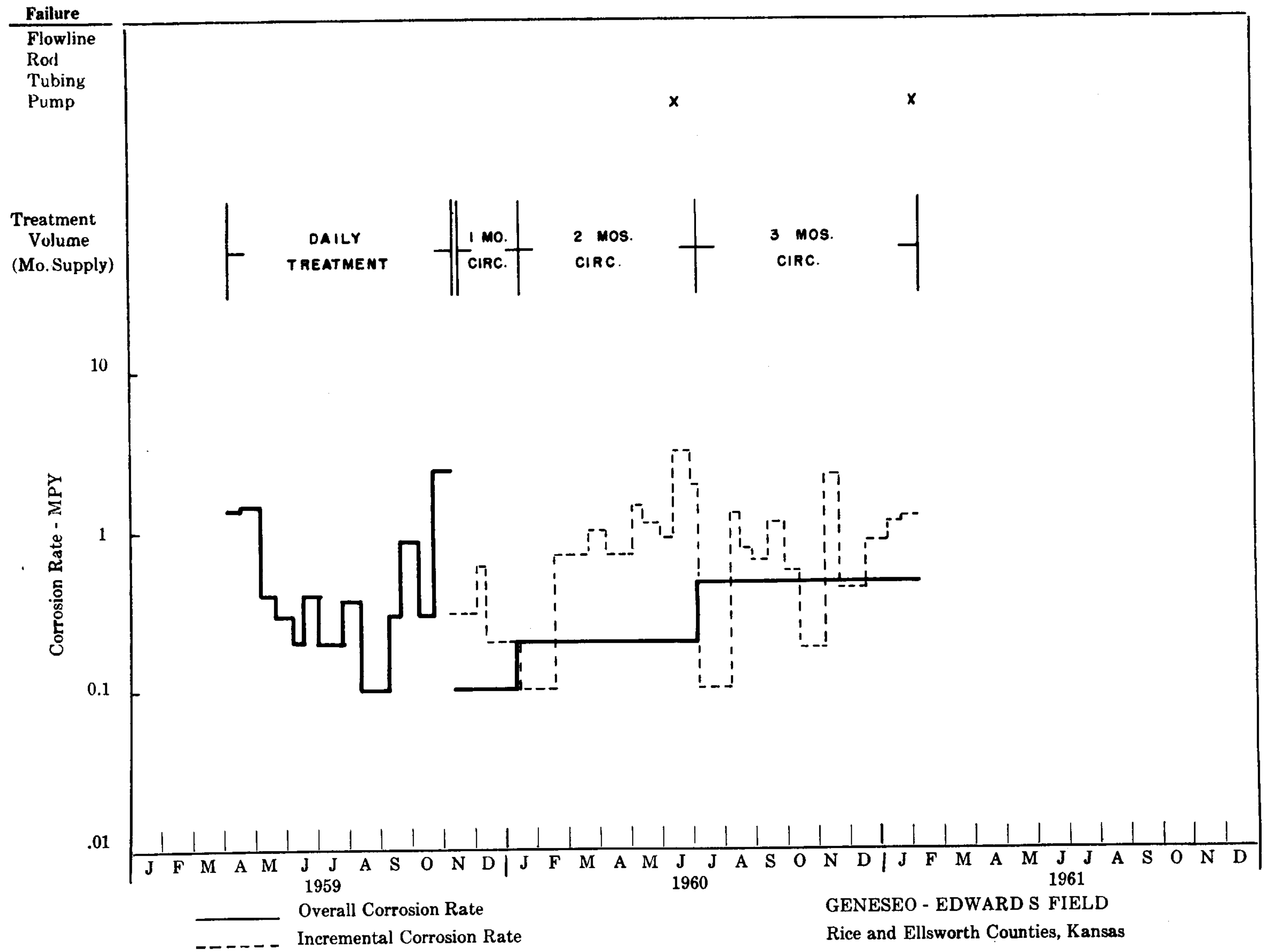
A. W. SHONYO NO. 6

FIG. I



H. W. MOLLHAGEN NO. 1

FIG. 2



GENESEO - EDWARD S FIELD

Rice and Ellsworth Counties, Kansas

EXTENDED PERIOD BATCH TREATING TEST DATA

TABLE II

Test Wells and Test Periods	(1) Treating Chemical	(2) Prod.Rate at Start of Test (BTFPD)	(3) Pump Submergence Opr. Fluid Level (Feet)	(4) Treatment Volume (Mo.Supply)	(5) Flushing Volume	(6) Test Length (Months)	(7) Incremental Corrosion Rate (MPY) Min.	(7) Max.	(8) Overall Extended Period Cor.Rate(MPY)	Remarks
B. B. Ainsworth No. 4										
1st: 1/12/60 - 4/5/60	1	180	214	2	circulated	3	0.61	2.98	0.22	
2nd: 4/5/60 - 8/5/60	1	188	214	3	circulated	4	0.50	2.64	0.19	
3rd: 8/5/60 - 9/16/60	1	181	168	3	circulated	1½	0.03	1.51	0.34	Test interrupted - remedial work.
S. Ainsworth "A" No. 2										
1st: 2/8/60 - 7/7/60	1	165	116	2	circulated	5	0.45	2.51	0.17	
2nd: 7/7/60 - 12/14/60	1	142	84	3	circulated	5	0.64	4.62	0.27	
3rd: 12/14/60 - 5/2/61	1	153	53	3	0.5 bbl.	4½	0.69	3.14	0.18	
L. Johnson "A" No. 2										
1st: 4/26/60 - 12/8/60	2	340	599	2	circulated	7½	0.10	6.90	0.80	
J. R. Lansing No. 1										
1st: 1/9/60 - 2/9/60	1	110	64 (PO)	2	circulated	1	0.49	0.59	lost in mail	Test interrupted - remedial work.
2nd: 3/7/60 - 6/14/60	1	237	64	2	circulated	3	0.84	5.08	0.51	Displaced annular fluids before treatment.
3rd: 6/14/60 - 12/14/60	1	182	64	2	circulated	6	0.42	2.54	0.16	
4th: 12/14/60 - 5/2/61	1	165	34	2	0.5 bbl.	4½	0.63	2.07	0.15	
J. R. Lansing "A" No. 1										
1st: 1/8/60 - 4/5/60	1	480	573	2	circulated	3	0.38	1.59	0.10	
2nd: 4/5/60 - 10/17/60	1	480	573	3	3.5 bbls.	6	0.40	4.01	0.17	
3rd: 10/17/60 - 5/2/61	1	387	400	3	3.0 bbls.	4½	0.78	3.25	0.23	
A. H. Meyer No. 8										
1st: 1/9/60 - 4/4/60	1	962	1846	2	circulated	3	0.61	2.03	0.22	
2nd: 4/4/60 - 10/17/60	1	962	1846	3	7.0 bbls.	6	0.50	1.88	0.16	
3rd: 10/17/60 - 5/2/61	1	1019	1178	3	7.0 bbls.	4½	0.84	2.06	0.13	
4th: 5/2/61 - 10/13/61	1	1077	1193	3	5.0 bbls.	5½	0.58	6.60	1.38	

Extended Period Batch Treating Test Data
Page 2

Test Wells and Test Periods	(1)	(2)	(3)	(4)	(5)	(6)	(7)		(8)	Remarks
H. W. Mollhagen No. 1										
1st: 11/18/59 - 1/14/60	3	265	301	1	circulated	2	0.20	0.60	0.10	
2nd: 1/25/60 - 7/6/60	3	265	301	2	circulated	5½	0.10	3.20	0.20	
3rd: 7/6/60 - 2/11/61	3	247	487	3	circulated	7	0.10	2.21	0.48	
H. W. Mollhagen No. 8										
1st: 4/1/60 - 10/28/60	2	281	609	1½	circulated	7	0.30	2.30	0.10	Displaced annular fluids before treatment.
2nd: 10/28/60 - 5/8/61	2	285	924	1½	4.0 bbls.	6½	0.20	2.40	0.10	
P. Nickel No. 4										
1st: 1/13/60 - 4/12/60	3	595	1026	1	4.0 bbls.	3	0.07	0.72	0.14	
2nd: 4/12/60 - 10/19/60	3	778	1026	2	5.5 bbls.	6	0.01	1.48	0.06	
3rd: 10/19/60 - 8/9/61	3	778	1058	2	5.5 bbls.	9½	0.19	0.45	0.04	
4th: 8/9/61 - 3/12/62	3	776	1123	3	5.0 bbls.	7	0.01	0.20	0.06	
P. Nickel No. 9										
1st: 1/12/60 - 4/13/60	3	321	809	1	circulated	3	0.08	0.22	0.02	
2nd: 4/13/60 - 10/19/60	3	320	809	1½	circulated	6	0.05	1.55	0.08	
3rd: 10/19/60 - 8/9/61	3	320	783	1½	3.5 bbls.	9½	0.13	2.35	1.46	
4th: 8/9/61 - 3/12/62	3	340	799	3	3.5 bbls.	7	0.13	0.43	0.11	
W. S. Pickerill "A" No. 8										
1st: 1/13/60 - 4/12/60	3	195	42	2	circulated	3	0.31	1.21	0.08	
2nd: 4/12/60 - 10/19/60	3	195	42	3	circulated	6	0.21	1.48	0.11	
3rd: 10/19/60 - 8/9/61	3	194	321	3	1.5 bbls.	9½	0.06	0.35	0.04	Multi-chuck holder
4th: 8/9/61 - 3/12/62	3	194	429	3	1.5 bbls.	7	0.01	0.21	0.04	
Wm. Ploog "A" No. 6										
1st: 3/31/60 - 10/28/60	2	785	1263	3	5.5 bbls.	7	0.40	1.20	0.10	
2nd: 10/28/60 - 5/5/61	2	785	1263	3	5.5 bbls.	6	0.30	4.30	0.10	

Extended Period Batch Treating Test Data
Page 3

Test Wells and Test Periods	(1)	(2)	(3)	(4)	(5)	(6)	(7)		(8)	Remarks
A. W. Shonyo No. 2										
1st: 4/1/60 - 10/28/60	2	576	1156	2	4.0 bbls.	7	0.04	1.20	0.10	
2nd: 10/28/60 - 5/5/61	2	573	1187	2	4.0 bbls.	6	0.30	2.40	0.10	
A. W. Shonyo No. 6										
1st: 11/18/59 - 12/31/59	1	347	742	1	circulated	1½	0.60	2.90	1.10	Coupon holders non-insulated.
2nd: 12/31/59 - 4/6/60	1	347	896	2	circulated	3	0.61	2.32	0.17	
3rd: 4/6/60 - 8/31/60	1	347	896	3	circulated	5	0.23	1.27	0.16	
4th: 9/2/60 - 2/22/61	1	384	184	3	circulated	5½	0.20	10.50	1.20	Exposed to oxygen during pulling job.

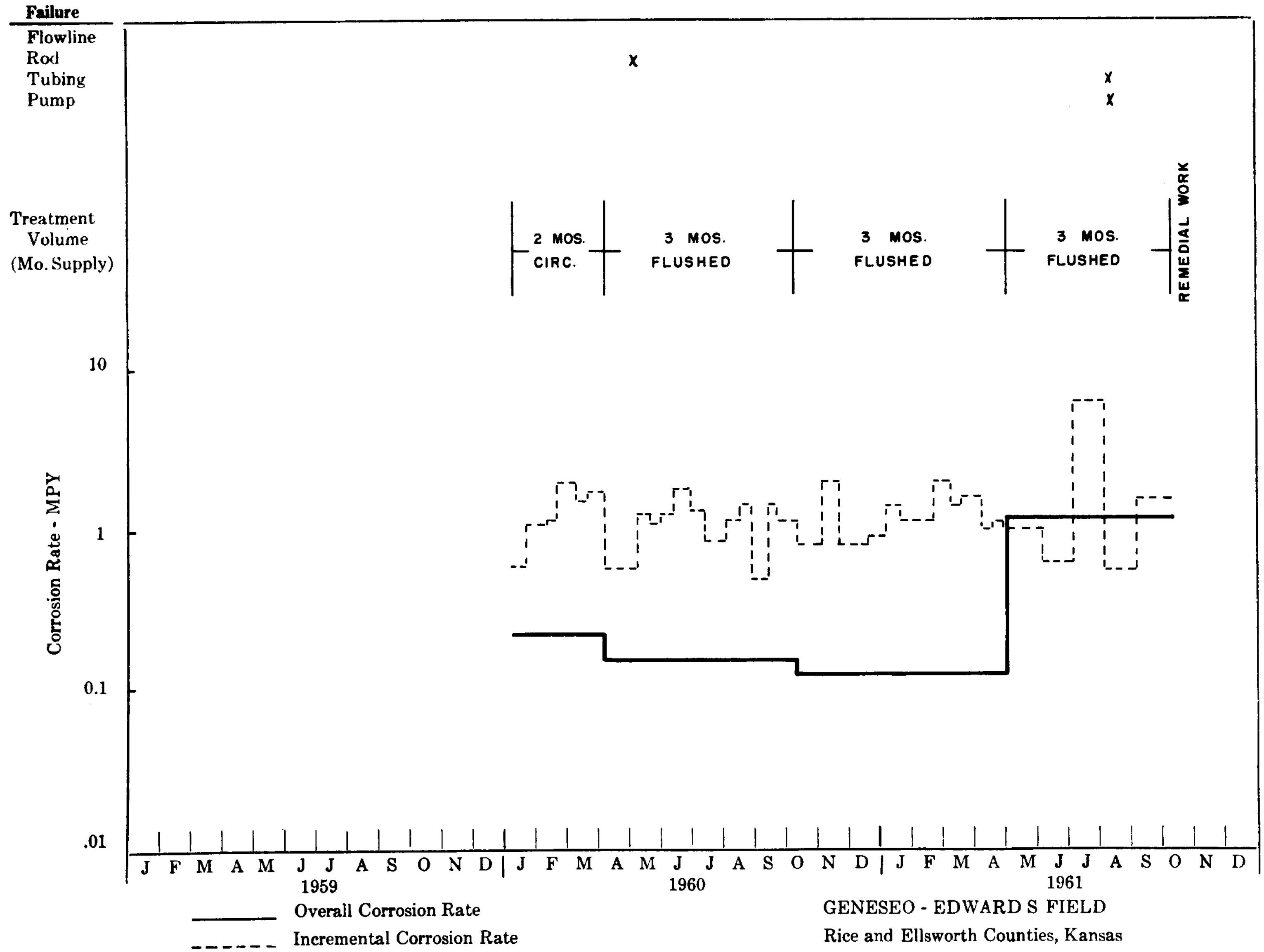
Coupon pony rods run on rod string in conjunction with Test No. 4. Rod No. 1 (directly above pump) 0.19 MPY; Rod No. 2 (middle of rod string) 0.02 MPY; Rod No. 3 (directly below polished rod) 3.46 MPY.

Test Wells and Test Periods	(1)	(2)	(3)	(4)	(5)	(6)	(7)		(8)	Remarks
J. M. Shumway No. 2										
1st: 3/31/60 - 10/28/60	2	313	605	3	circulated	7	0.20	2.50	0.40	Displaced annular fluids before treatment.
2nd: 10/28/60 - 5/8/61	2	322	635	3	4.5 bbls.	6	0.20	3.00	0.20	

195

A. H. MEYER NO. 8

FIG. 3

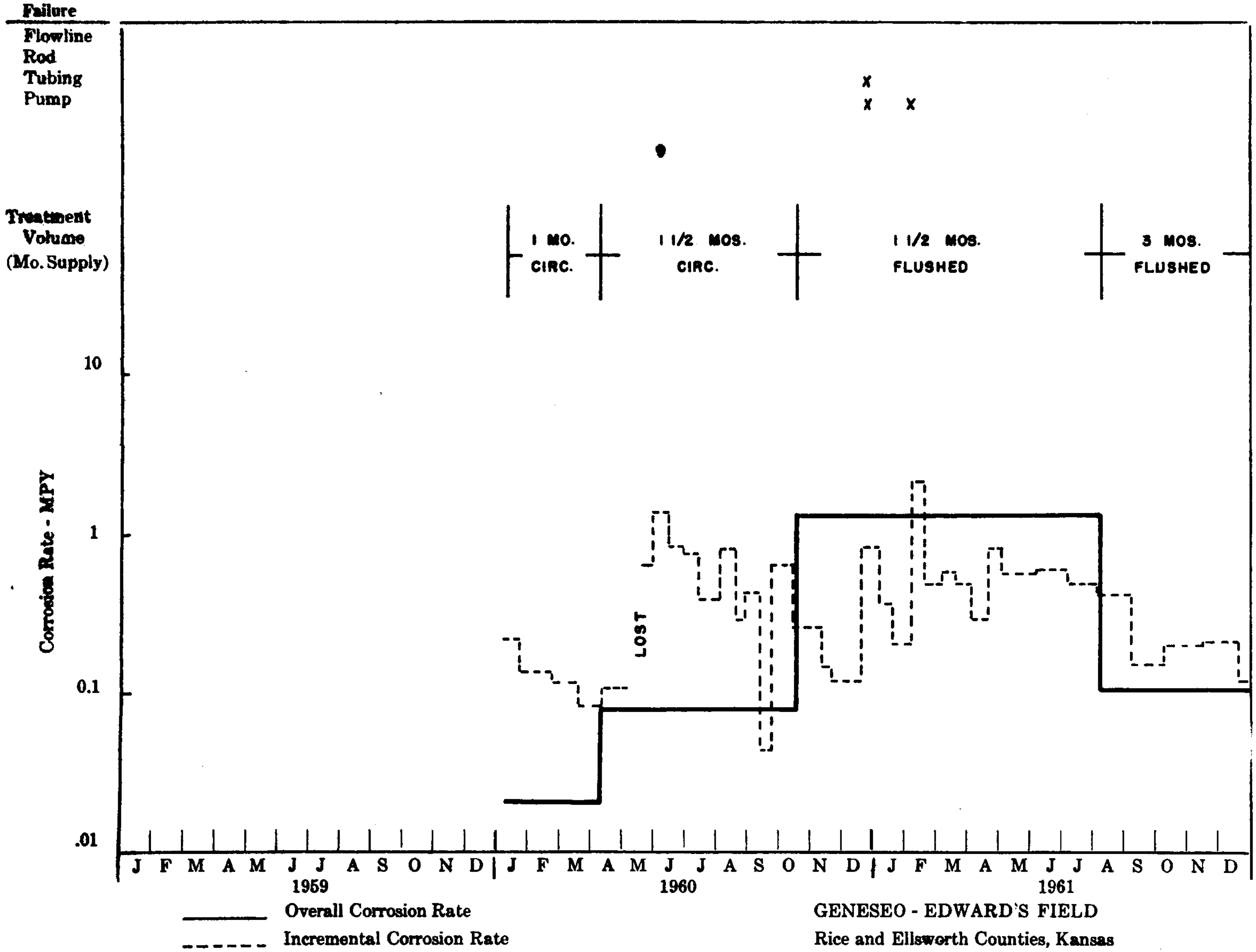


GENESEO - EDWARD S FIELD

Rice and Ellsworth Counties, Kansas

P. NICKEL NO. 9

FIG. 4



middle of the rod string, and directly below the polished rod. During this test, which was run in conjunction with Test No. 4, the overall measured corrosion rates at these 3 points were 0.19 mpy, 0.02 mpy, and 3.46 mpy, respectively. The measured results on the two lower test pony rods indicate that good corrosion protection has resulted throughout the tubing and rod string. The reason for the high rate (3.46 mpy), as observed on the test rod directly below the polished rod, has not been determined.

Tests have been completed on 2 pump-off wells in which the annular fluid volume is less than 100 ft. Encouraging data have been obtained on wells in this category; however, more testing is desired before definite conclusions can be formed.

Since the desired protection of less than 1.0 mpy has been obtained on all tests, with the exception of the four tests previously cited, all Arbuckle wells in the Geneseo-Edwards Field with fluid levels in excess of 100 ft of pump submergence are being treated with a 3 month supply of chemical and operated for 6 months before retreatment. The total number of our company's wells in Central Kansas on EPBT is currently 110 wells.

The coupons utilized in this testing program were furnished by our Research and Development Department and the three companies supplying inhibitor. Slight differences which are a function of the differences in the coupons used may be noticed on several of the graphs. Until January 1961, coupons furnished by us were utilized in checking the corrosion rates on H. W. Mollhagen No. 8 (Figure 5), Wm. Plogg "A" No. 6 (Figure 6), A. W. Shonyo No. 2 (Figure 7), and J. M. Shumway No. 2 (Figure 8). In January 1961, coupons furnished by a chemical company were substituted. It has been noted that the rates measured by the coupons furnished by the chemical companies are generally higher than the rates measured by the coupons furnished by us. This is further evidenced by the fact that our coupons were sandwiched between two chemical company coupon check periods during February 1961. The measured corrosion rate dropped considerably during our check period. This observation may be noted on the curves for A. W. Shonyo No. 2 (Figure 7) and J. M. Shumway No. 2 (Figure 8).

SUMMARY

The success of EPBT appears to be a function of the annular fluid volume. To support this belief, the following illustration (Figure 9) and explanation is offered:

FIGURE 9

Let us assume that this is an Arbuckle well producing 15 BO and 225 BW per day with 300 ft of fluid above the perforations in the mud anchor. During conventional treatment, this well received 1 pint of inhibitor per day or 3-1/2 quarts per week. With EPBT, this well will receive 11 gallons of inhibitor and will be flushed with 3 bbl of fluid. The well will then be produced for 6 months before retreating.

What happens in this EPBT is essentially this: the 11 gallons of oil-soluble, water-dispersible inhibitor will mix in the 300 ft of oil column in the annulus and form a liquid with a high inhibitor concentration. When the 3 bbl of flush are dumped down the annulus, it displaces a like volume of the inhibitor-oil mixture through the mud anchor perforations and into the tubing string. This inhibitor-oil mixture will then deposit the initial inhibitor film on the rod and tubing strings as it is pumped up the tubing string. The remaining inhibitor-oil mixture that was not displaced by the flush then serves as a reservoir of inhibitor for film repairing. The normal movement of the tubing while the well is pumping and the normal fluctuations in the fluid level will allow periodic feeding of the inhibitor-oil mixture from the annular reservoir to the tubing for the remainder of the extended period. Even though this feedback of inhibitor is in lesser volume than the initial flushing, the amount of inhibitor is adequate to repair any damage that has occurred to the original film.

The test program as conducted has indicated that EPBT can be successfully applied to all corrosive wells that have enough pump submergence to provide a sufficient annular reservoir for the inhibitor-oil mixture. The minimum annular volume requirement has been tentatively selected as 100 feet of pump submergence. A treating program of this nature will offer the following advantages:

1. Reduction in amount of chemical used.
2. Reduction in the amount of time required to treat wells.
3. Assurance of adequate corrosion protection during winter months when many wells are inaccessible.

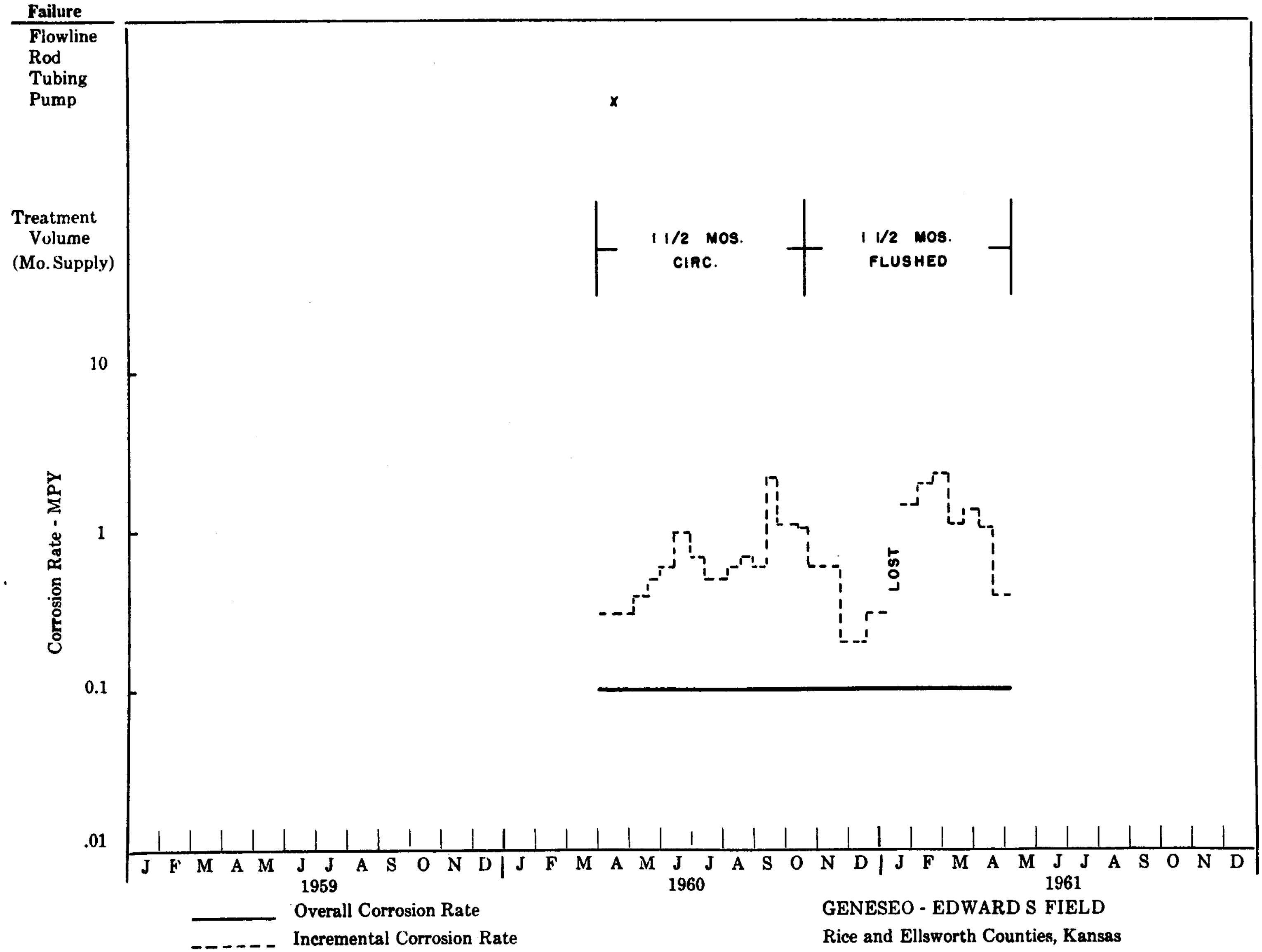
In summary, "Extended Period Batch Treating" can afford good corrosion protection at reduced cost.

ACKNOWLEDGMENTS

The author wishes to express his appreciation to the management of Continental Oil Company for permission to prepare and present this paper. Appreciation is also extended to Mr. N. O. McDaniel, an engineer formerly with Continental Oil Company, who did much of the initial work on extended period batch treating in Central Kansas.

H. W. MOLLHAGEN NO. 8

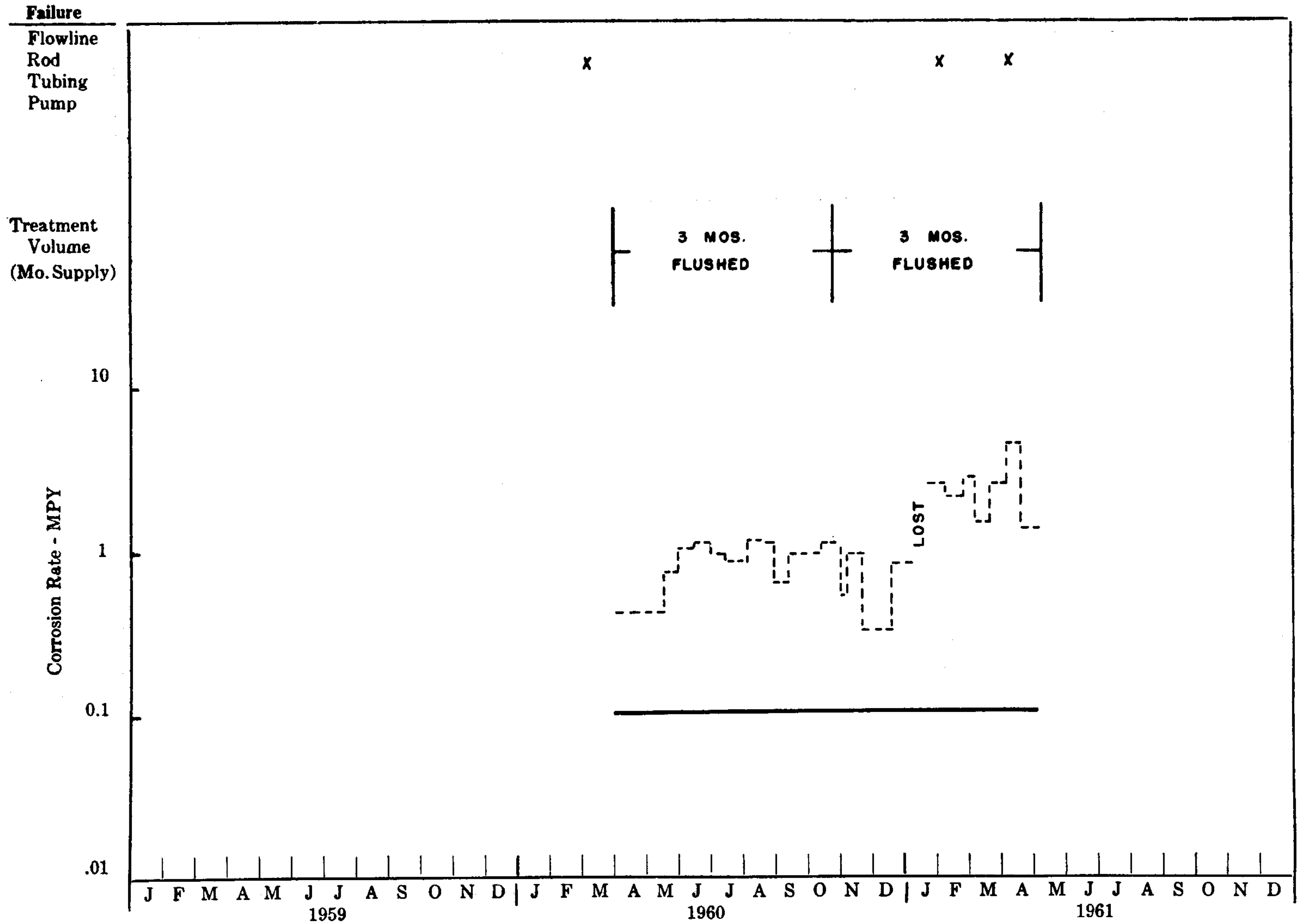
FIG. 5



GENESEO - EDWARD S FIELD

Rice and Ellsworth Counties, Kansas

WM. PLOOG "A" NO. 6
FIG. 6

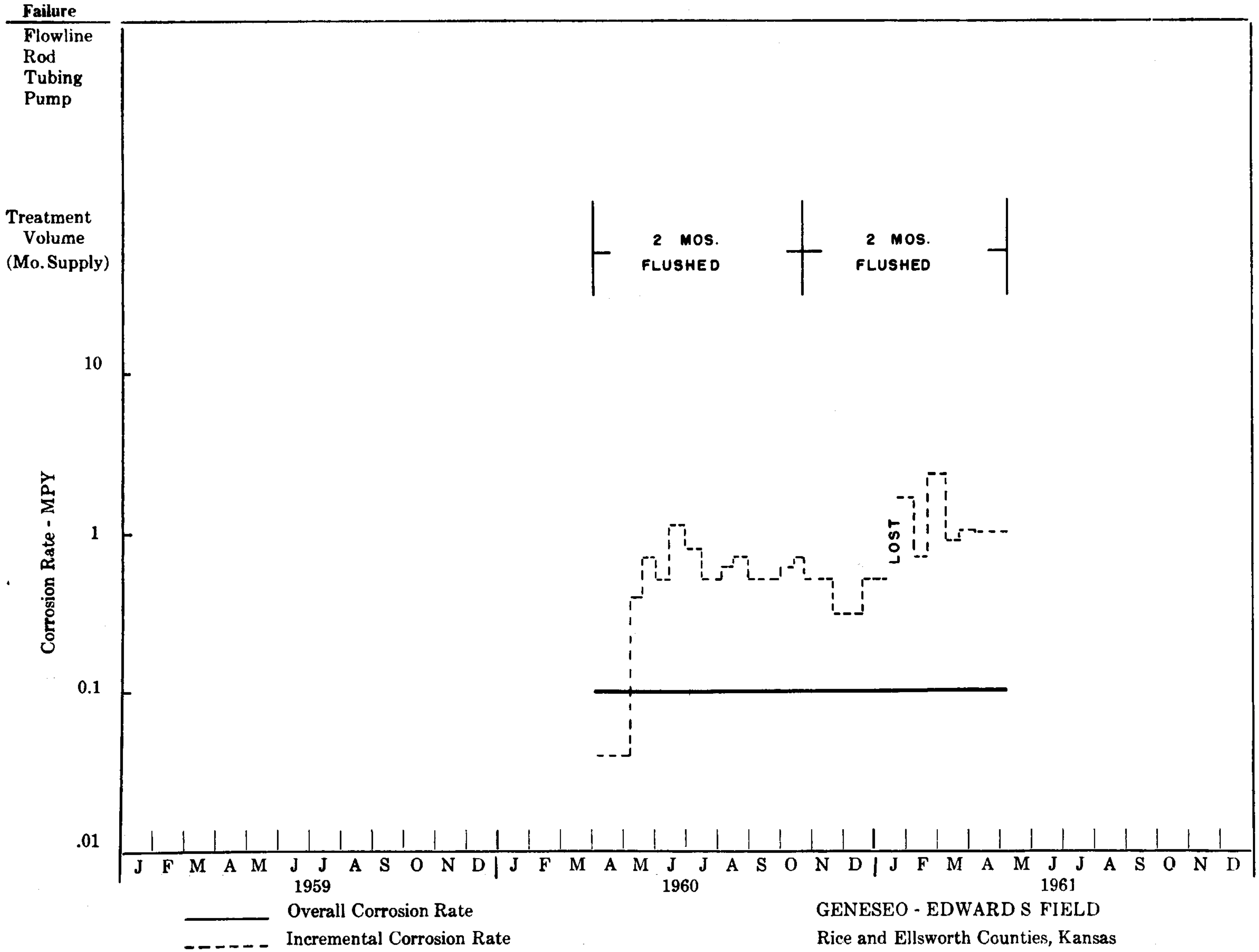


Overall Corrosion Rate
Incremental Corrosion Rate

GENESEO - EDWARDS FIELD
Rice and Ellsworth Counties, Kansas

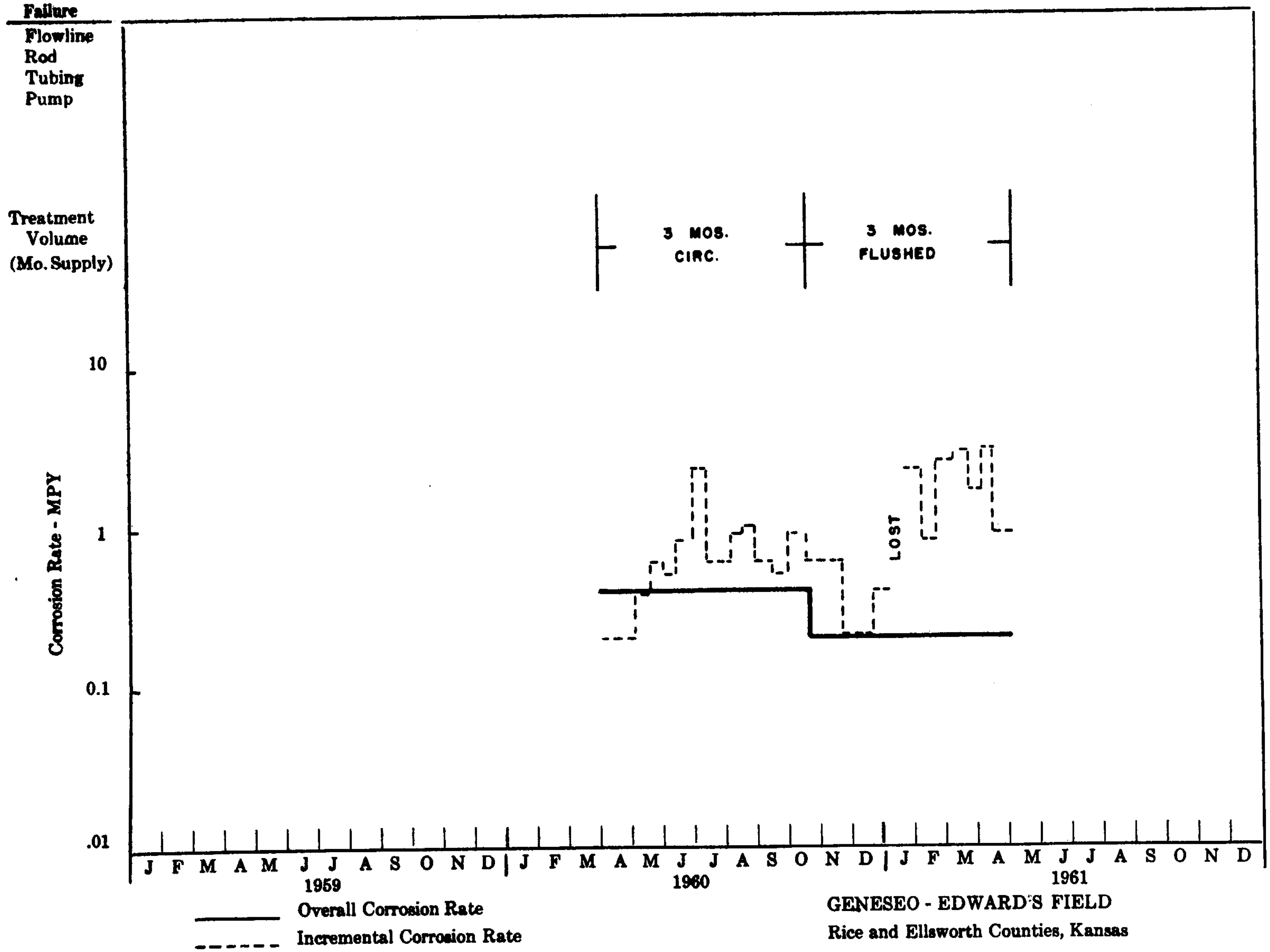
A. W. SHONYO NO. 2

FIG. 7



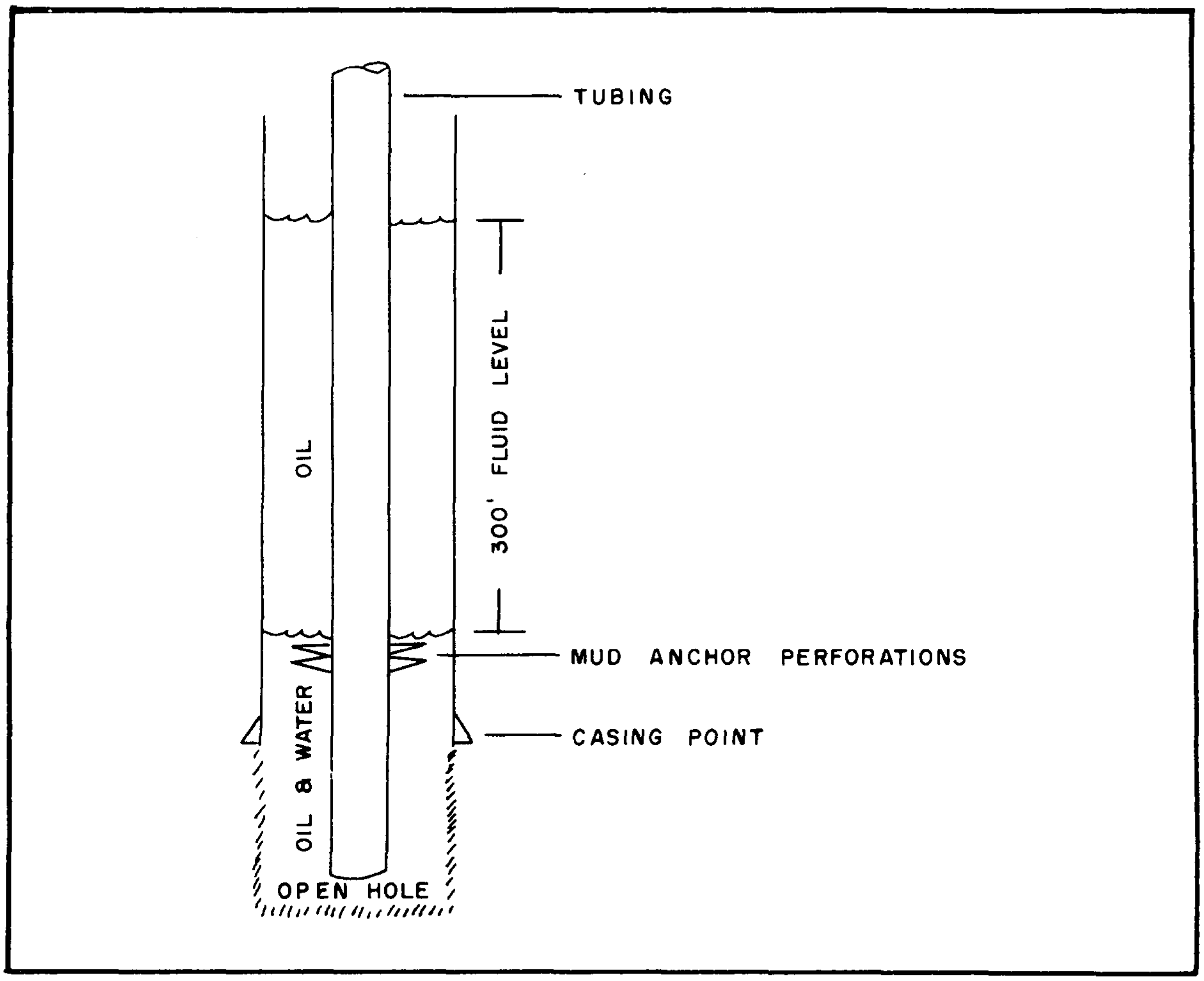
GENESEO - EDWARD S FIELD
Rice and Ellsworth Counties, Kansas

J. M. SHUMWAY NO. 2
FIG. 8



GENESEO - EDWARD'S FIELD
Rice and Ellsworth Counties, Kansas

FIG. 9


TUBING
OIL
300' FLUID LEVEL
MUD ANCHOR PERFORATIONS
OIL & WATER
CASING POINT
OPEN HOLE