Mixed String Sucker Rod Tests

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INTRODUCTION

Sucker rods are one item of production equipment that must be tested and evaluated in actual operations. None of the regular tests used to evaluate steel can duplicate down-hole conditions. Sucker rod manufacturers' recommendations, then, are based on laboratory information and field experience with the material. Since the manufacturers are dependent on the users for information on field experience, the quality of these data depends on the tests conducted by the users. It is this phase of the subject, testing, that will be discussed in this paper.

The procedure to be discussed and recommended is the alternate rod, mixed string method of testing. Data are presented to illustrate the quality of information that can be obtained and the obvious advantages of this method of testing over similar well tests or consecutive tests in the same well.

The test strings discussed in this report were designed (1) to compare the performance of different grades of sucker rods and (2) to compare the performance of competitive sucker rods. These tests were run in inhibited sour Arbuckle wells in Western Kansas.

The test strings were designed and evaluated as follows:

(1) Each test string was designed to compare three rods.
(2) The rods were installed alternately so that every third rod was the same.
(3) A dynamometer survey was run at the beginning of the test and any operating difficulties corrected. The wells were rechecked at six month intervals to insure the continuation of good operating conditions.
(4) All wells were inhibited with the best inhibitor for that area.
(5) Tests comparing 1036 steel were designed for a maximum rod stress of 20,000 psi.
(6) Tests to evaluate the higher strength rods were designed for 26,000 psi maximum rod stress.
(7) All rods were numbered to insure proper placement and identification.
(8) Sections of the broken rods were tagged and retained for metallurgical studies.
(9) Samples of broken rods were given to the respective manufacturers.
(10) Each test was run for two years or until the break frequency became prohibitive.
(11) The cost of the test would be borne entirely by Cities Service Oil Company.

The first test string was installed in April 1955, and the other 21 test strings were installed as wells needed replacement strings. Two purposes were served by this procedure: (1) the cost of the testing program was reduced because only necessary pulling and equipment replacements were made and (2) all of the test strings were installed in problem wells.

RESULTS OF THE TEST

The primary interest was in 1036 and 4600 steels; therefore, these steels have been shown separately in the results. Steels, other than these, have been placed in the Special category and, to implement the comparision, have been designated as low, medium, or high indicating a tensile strength comparable to 1036, 4600, and E3310 steels, respectively.

The first six tests were completed in June 1957 and the results summarized in Table 1. A comparison of the "breaks/100 rods" suggests that these steels gave comparable service. It is true that the average number of failures indicates comparable performance but the summary in Table II shows that two manufacturers' rods were responsible for the majority of failures in all grades. Manufacturers D and E. with 53 per cent of the rods tested experienced 94 per cent of the failures. A statement such as this immediately suggests that these rods were in a more severe service than the other rods.

The fact that these rods were not in more severe service is illustrated in Fig. 1. If the service had been the controlling factor, all of the rods in that well should have given trouble. Such was not the case. In all these cases of poor performance only one rod gave trouble. This is also true of Test String 10 and 10 A. After one year's service the bad rods were replaced with the same grade. Both of these rods gave trouble but, during the two year period, the other two rods on test in this well did not experience a single failure.

The information obtained from the first six test strings established the worth of the testing program, indicated the advantages of mixed string testing, and the program was expanded to include several comparisons that were not considered in the orginal program. Twenty-two test

TABLE I

SUCKER ROD PERFORMANCE BY GRADES

Tests Completed	1036 Steel			4600 Steel			Special*			Totals		
	No. of Rods	Breaks	Breaks/ 100 Rods	No. of Rods	Breaks	Breaks/ 100 Rods	No. of Rods	Breaks	Breaks/ 100 Rods	No. of Rods	Breaks	Breaks/ 100 Rods
6	272	19	7.0	404	37	9.2	193	20	10.4	869	76	8.7
9	359	19	5.3	556	49	8.8	372	48	12.9	1287	116	9.0
13	580	20	3.4	824	69	8.4	415	55	13.3	1819	144	7.9
18	798	29	3.6	1230	84	6.8	415	55	13.3	2443	168	6.9
22	1111	29	2.6	1456	91	6.3	415	55	13.3	2982	175	5.9

*Includes special alloys of low (1036), medium (4600), and high (E 3310) tensil strength.

TABLE II

RESULTS OF FIRST SIX TESTS BY MANUFACTURER AND GRADE

	Rods Tested			Breaks			
	No.		% of Total	No.		% of Total	
Steel: 1036	7/8	3/4	Rods	7/8	3/4	Rods	Breaks/ 100 Rods
A	17	75	10.6	0	1	1.3	1.1
C	36	99	15.5	4	14	23.7	13.3
B	20	25	5.2	0	0	0	0
	73	199	31.3	4	15	25.0	7.0
Steel: 4600							
A	38	54	10.6	0	0	0	0
C	55	126	20.8	3	26	38.2	16.0
B	19	71	10.4	1	0	1.3	1.1
D	0	41	4.7	0	7	9.2	17.1
	112	292	46.5	4	33	48.7	9.2
Steel: Special							
C (low)	35	56	10.5	4	0	5.3	4.4
A (high)	0	48	5.5	0	0	0	0
E (high)	0	47	5.4	0	16	21.1	34.0
E (high)	0	7	0.8	0	0	0	0
	35	158	22.2	4	16	26.3	10.4
TOTALS	220	649	100.0	12	64	100.0	8.7

strings were installed and the entire program required approximately four years to complete. The trends established by the first tests became more pronounced as more information became available. These data are summarized in Tables I and III.

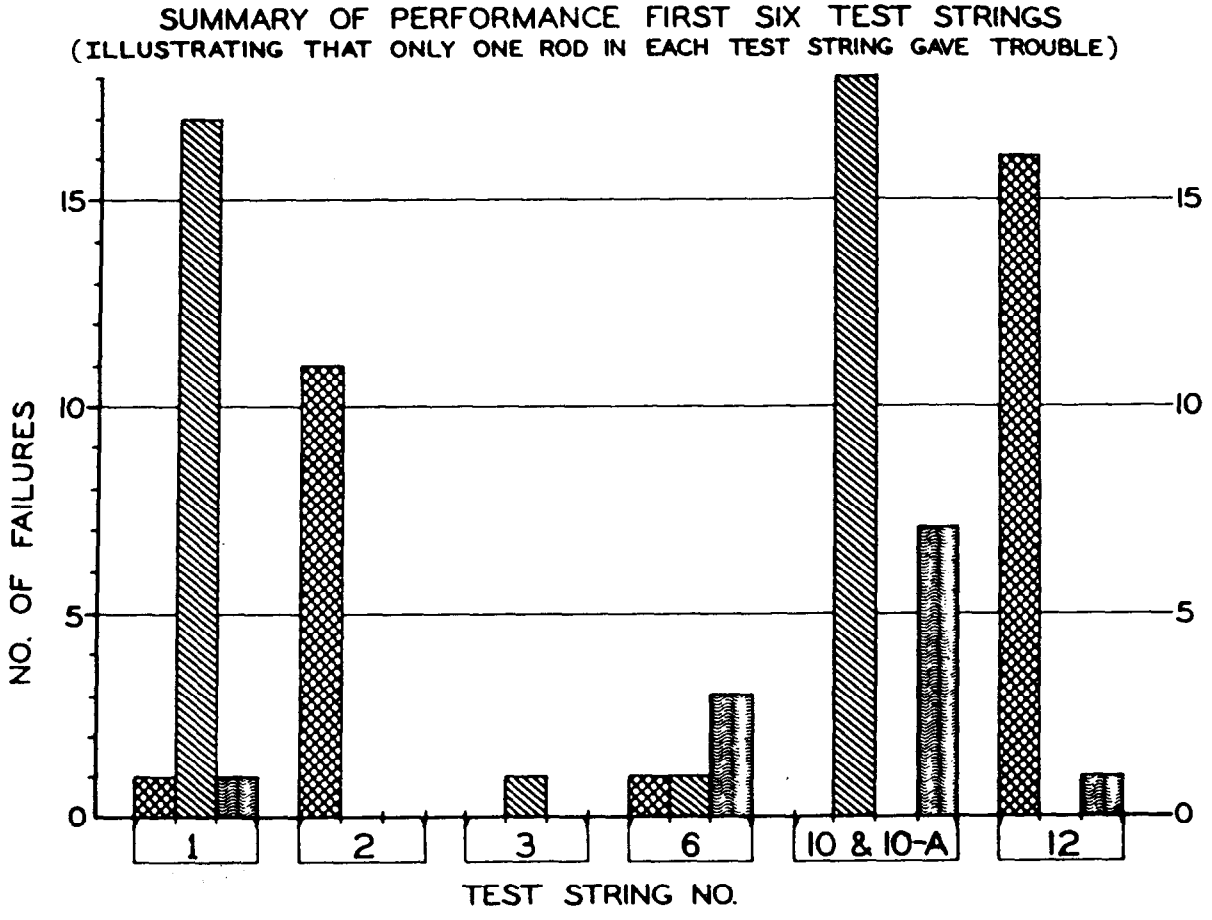

FIGURE 1

TABLE III

ROD PERFORMANCE BY MANUFACTURER

Manufacturer	No. of Rods 7/8	No. of Rods 3/4	% of Rods	Breaks	% of Breaks	Breaks per 100 Rods
D	206	451	22.0	82	46.8	12.5
F	115	149	8.9	31	17.7	11.7
E	98	416	17.2	25	14.3	4.9
G	113	214	11.0	14	8.0	4.3
B	132	286	14.0	8	4.6	1.9
H	115	148	8.8	5	2.9	1.9
A	139	400	18.1	10	5.7	1.9
TOTALS	918	2064	100.0	175	100.0	

CONCLUSION

All of the rods used in these tests, except two strings, were picked up from suppliers' stock; therefore, the results of these tests are not shaded by rods prepared especially for these tests. The following conclusions were drawn from these data:

(1) Carbon manganese (C-1036) sucker rods, as a whole, were superior to other types of steel in the inhibited sour crude environment.

(2) Manufacturers' service recommendations (C-1036 for "non-corrosive" service and 4600 for "corrosive" service) were not substantiated by these tests.

(3) The quality of sucker rods varies between manufacturers and between grades of the same manufacturer.

(4) With these data, it should be possible to select sucker rods, both grade and manufacturer, that would perform satisfactorily in inhibited sour Arbuckle wells.

This information was used to select rods for inhibited sour crude service and the results were exactly as expected. Failures that had been attributed to poor inhibition were actually the result of poor quality rods and the use of good quality rods substantially improved the effectiveness of the inhibition program. This experience illustrates the difficulty and expenses that can result when too many assumptions are made.

If these tests were repeated today the results would not be the same. All of the manufacturers, except one, found the cause of their trouble. In all cases it was some phase of the manufacturing process that was to blame.

As a direct result of these tests, sucker rod quality was substantially improved. Because of this improvement in quality, the industry as well as Cities Service Oil Company derived considerable benefit from this testing program. Mixed string testing, whether individual or cooperative, is a practical and effective method of obtaining reliable information.

REFERENCE

1. Koger, W. C., "Results of Mixed String Sucker Rod Tests", paper presented at the National Association of Corrosion Engineers, South Central Region Conference, New Orleans, Louisiana, October, 1958.

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