FIELD TESTS TO DETERMINE CEMENT BOND QUALITY AFTER YEARS OF PRODUCTION

PAUL E. PILKINGTON and JAMES B. SCOTT
Continental Oil Company

INTRODUCTION

The "RUFF-COTE"® * process, a resin-sand coating applied to the external surface of casing to provide an improved bond between the casing and cement, has now been widely used in oilfield completions for the past ten years. This process has been applied to well casing from 2-7/8 in. slim holes to 20-in. surface casing in ultra-deep wells. Additional application has been on intermediate casing strings as well as on offshore platform jacket legs. Successful field usage of this process in thousands of wells has demonstrated its effectiveness in providing a good bond between the cement and casing.

One area, however, that had not been previously evaluated was how long the initial cement-to-casing bond is maintained after well completions operations such as perforating, fracturing or acidizing, and normal stresses applied during production. In order to properly evaluate the resin-sand coating, it was necessary to analyze wells that had been completed both with and without the resin-sand coating and had been producing for a number of years. Continental's Sacatosa Field in Maverick County, Texas, fitted all requirements for a good field test.

The Sacatosa Field located in South Texas produces from the shallow San Miguel sand at a depth ranging from 1300 to 1700 feet. The wells were drilled with a light water-base mud and completed with either 4-1/2 in. or 5-1/2 in. casing. Casing was run to TD and cemented to the surface. A well plot of Sacatosa Field showing the test area is presented in Fig. 1.

The casing was perforated with a single-plane horizontal jet gun consisting of either three or eight shots within 24 to 48 hours after cementing. All wells were then hydraulically fractured with a sand-oil treatment.

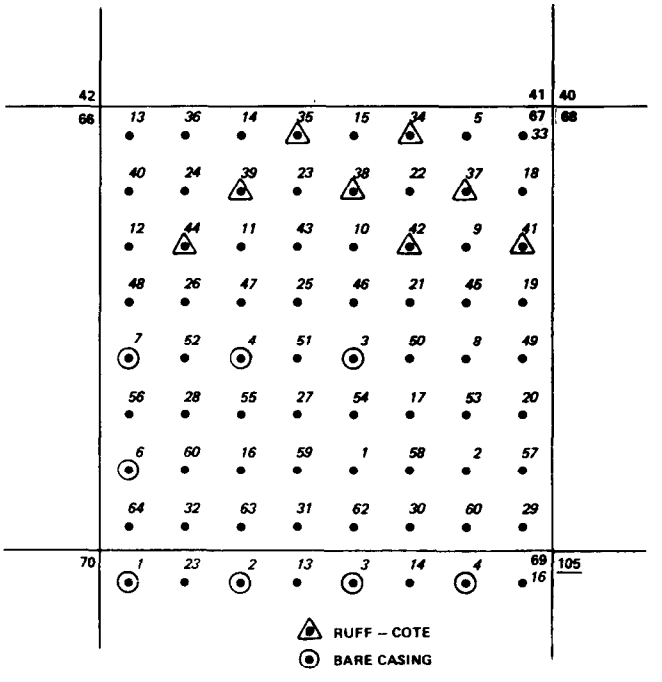

FIG 1—RUFF-COAT VS BARE CASING COMPLETION MAP, SACATOSA FIELD, MAVERICK CO., TEX.

TEST PROPOSAL

The initial field development during the period 1959 to 1963 consisted of drilling wells on 40-acre spacing and completing essentially as above, except that the "RUFF-COTE" process was not available during this period. Therefore, these wells were com-

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pleted through the pay section with mill-varnished casing.

The second stage of development that began in the middle 1960's included the resin-sand coating on the bottom section of the casing. Coated casing was run on the bottom three joints covering the interval from total depth to about 50 ft above the pay zone. This total interval was approximately 120 ft in each well. Cementing, perforating and fracturing operations were essentially the same as in the earlier wells.

The object of this field project was to evaluate the cement bond quality of these wells after several years of normal production. There were wells that were completed and produced under similar conditions; some without the resin-sand coating and some with the resin-sand coating. The test procedure was as follows:

1. Pull rods and tubing and load hole with lease crude.
2. Run gamma ray casing collar log for correlation with previous logs.
3. Run Cement Bond Log (CBL) consisting of (a) amplitude curve, (b) variable density type display (MSG), and (c) scope pictures.
4. Run rods and tubing back in well and put on production.

Comparison was then made of Cement Bond Logs run on initial completion with those run after producing for approximately six to seven years for the wells with the resin-sand coating. No initial CBL's were run during completion on bare-pipe wells. Therefore, no direct comparison of before and after conditions could be made on these wells. However, evaluation of the quality of cement job was made based on a comparison of the bare-pipe wells and those wells to which the resin-sand coating was applied.

FIELD TESTS

The pilot project consisted of running CBL's and gamma ray logs on January 28-29, 1975, in six wells-three with the resin-sand coating and three with bare casing. This phase of the project indicated that damage to the cement job had occurred (probably due to perforating) in the bottom three joints of the wells with bare casing, while the wells with the resin-sand coating on the bottom three joints showed no damage. This indicated the resin-sand coating was all good; bare casing was all poor.

The second phase of the project consisted of repeating the logging procedure in five coated wells and five bare-casing wells. The logs were run on April 1-3, 1975. In this phase, the gamma ray casing collar log (GR-CCL) was run only for correlation but would have been run over a longer section if bad cement was indicated by the CBL. Of the total of 16 wells logged during this study, three coated wells and three bare-pipe wells will be discussed in detail. It was not feasible to reproduce all logs for this article. However, well data and logging results are summarized on Table 1.

TABLE 1—WELL COMPLETION DATA

Well #	Completion Date	Perforating Tool	Perforations	PBTD	Fracturing Treatment	"RUFF-COTE" Interval	Intervals With Bond Damage
67-34	7/1/68	3 way jet	1611	1680	25,000 gallons 90,000 # sand	1560-1681	None
67-35	6/22/68	3 way jet	1542	1632	25,000 gallons 90,000 # sand	1514-1635	1442-1460
67-37	7/4/68	3 way jet	1650	1699	25,000 gallons 90,000 # sand	1576-1697	1526-1530 1571-1574
67-38	6/29/68	3 way jet	1596	1654	25,000 gallons 90,000 # sand	1536-1656	None
67-39	6/26/68	3 way jet	1560	1620	25,000 gallons 90,000 # sand	1502-1623	1492-1494
67-41	7/6/68	3 way jet	1660	1716	25,000 gallons 90,000 # sand	1595-1716	1530-1562
67-42	7/3/68	3 way jet	1653	1694	25,000 gallons 90,000 # sand	1574-1695	1550-1574
67-44	6/24/68	3 way jet	1570	1632	25,000 gallons 90,000 # sand	1511-1632	None
67-3	11/6/59	8 way jet	1633	1688	60,000 gallons 90,000 # sand	---------	1550-1668
67-4	11/10/59	8 way jet	1611	1650	60,000 gallons 90,000 # sand	---------	1600-1616
67-6	11/14/59	8 way jet	1647	1680	60,000 gallons 90,000 # sand	---------	None
67-7	11/28/59	8 way jet	1608	1653	60,000 gallons 90,000 # sand	---------	1520-1554
69-1	5/31/60	8 way jet	1668	1688	65,000 gallons 90,000 # sand	---------	1648-1660
69-2	6/1/60	8 way jet	1688	1712	52,000 gallons 90,000 # sand	---------	None
69-3	7/26/60	8 way jet	1656	1696	67,000 gallons 90,000 # sand	---------	None
69-4	7/29/60	8 way jet	1666	1700	64,000 gallons 90,000 # sand	---------	1610-1700

WELLS COMPLETED WITH THE RESIN-SAND COATING

General

Casing on all wells completed with the resin-sand coating was 4-1/2 in., 9.5 lb set in a 6-3/4 in. (bit diameter) hole. After cementing and perforating with a three-way frac-jet, all wells were fractured with 25,000 gal. lease crude plus 90,000 lb sand. Tubing, pump and rods were run and the wells were placed on production. Rods, pump and tubing were pulled prior to running the CBL's in January and

April, 1975, and were rerun after logging.

N. J. Chittim 67 - 35

This well was completed on June 22, 1968. Casing was cemented at 1635 ft with 113 sacks type "H" with 8% gel plus 85 sacks type "H" with 2% gel. A cement bond log run found good bonding in the interval of interest. (Figure 2) The well was perforated at 1542 ft.

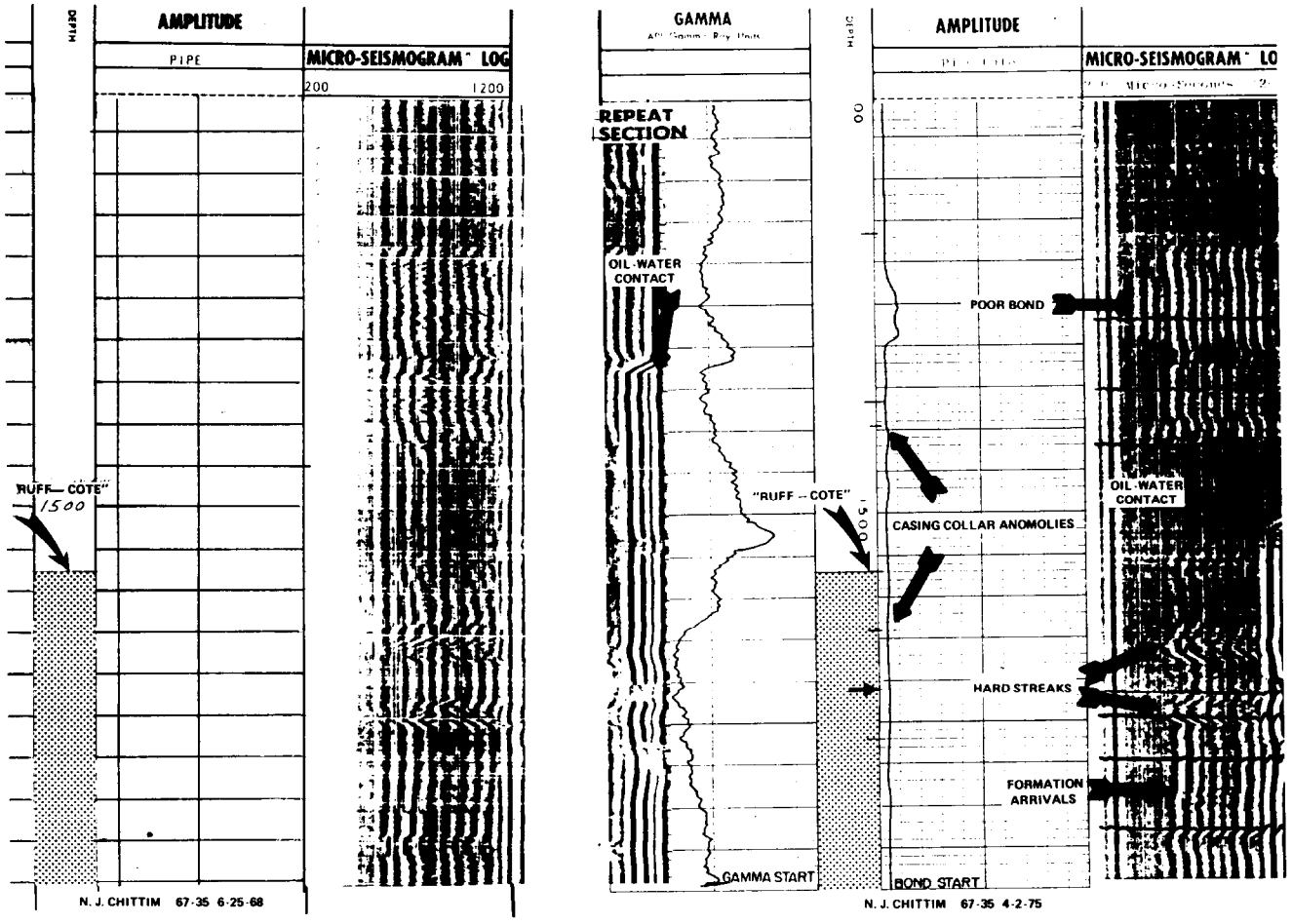

FIGURE 2

On April 2, 1975, GR-CCL and CBL were run. The CBL showed good bond through the coated section with deterioration of bond occurring above the coated section in the interval 1442-1460 ft. The MSG confirms the amplitude curve. The interval noted as poor bond on the MSG shows pipe ring coming in ahead of the formation arrivals. No pipe ring was present in the same interval on the original CBL (previous log section).

The repeat section was logged first, then the section was relogged. Crude was being flowed to maintain the fluid level in the casing, while logging was in progress. Water in the wellbore was displaced out the perforations by the additional hydrostatic head. This is shown by the downward displacement of the oil-water fluid interface on the MSG. The water may be produced water as the well was reported to have produced 825 bbl water in 1974. The fracture is indicated by the discontinuity in the fluid wave opposite the perforations.

Some anomalies appeared on the CCL which were neither collars nor perforations. The anomalies, which repeated perfectly on the repeat run, were not present on the original GR-CCL run in 1968. This may be indicative of casing damage.

N. J. Chittim 67 - 37

This well was completed on July 4, 1968. Casing was set at 1699 ft and cemented with 118 sacks type

"H" with 8% gel plus 87 sacks type "H" with 2% gel. A CBL (Fig. 3) run on July 6, 1968 indicated good bond. Casing was perforated at 1650 ft.

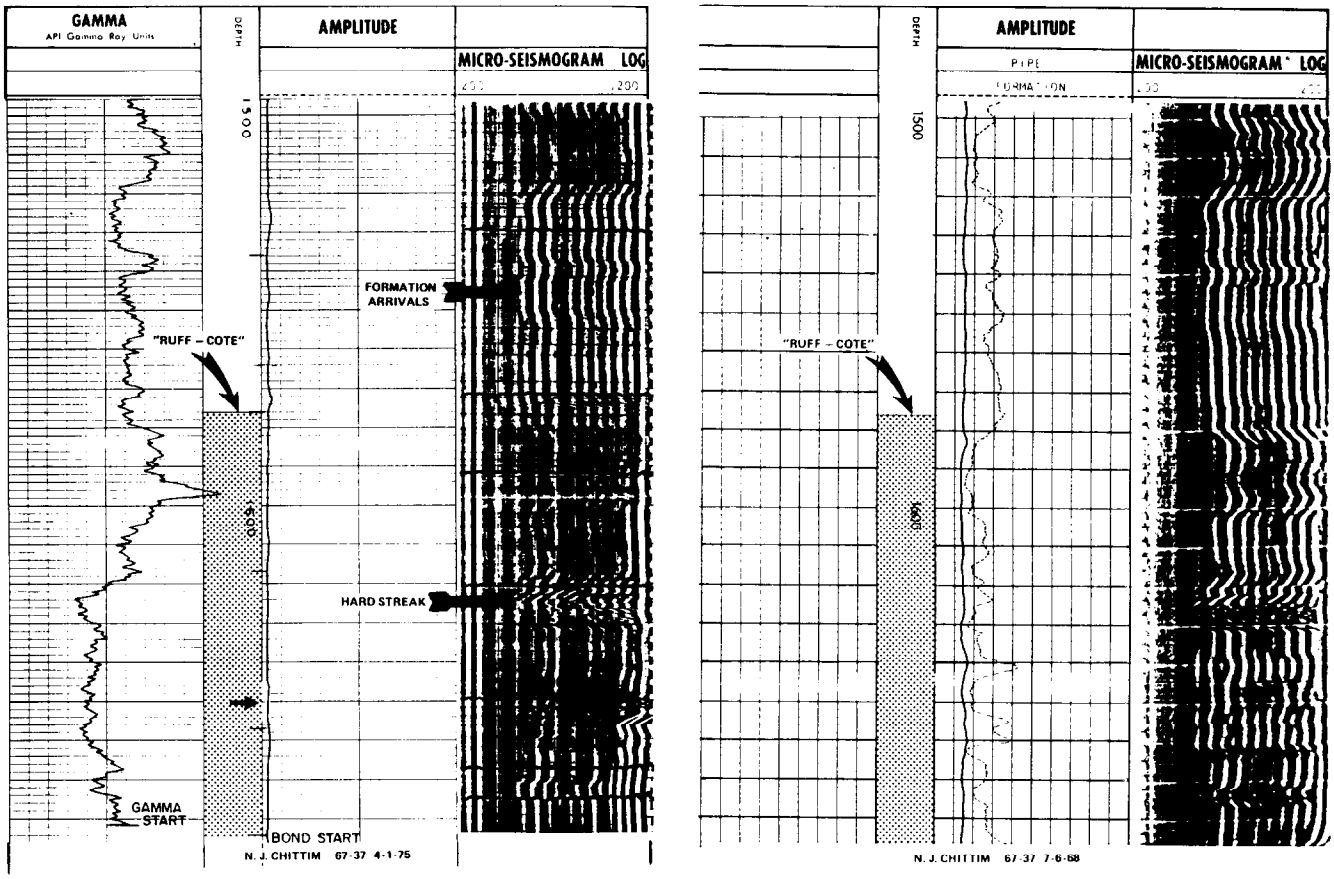

FIGURE 3

The CBL run on April 1, 1975, indicated no deterioration of bonding conditions in the coated interval. Pipe ring appears at 1526-1530 ft and 1571-1574 ft, indicating minor damage to the cement-casing bond.

The fluid wave opposite the perforations (immediately above the oil-water contact in the casing) is discontinuous, indicating the horizontal fracture.

N. J. Chittim 67 - 42

Well 67-42 was completed on July 3, 1968 with casing set at 1698 ft. Casing was cemented with 118 sacks type "H" with 8% gel plus 87 sacks type "H" with 2% gel. Good bond was present through and above the coated interval. The well was perforated at 1653 ft.

A CBL (Fig. 4) run on January 29, 1975 indicated good bond through the coated interval. The amplitude kicks at 1624 ft and 1644 ft are caused by formation signals entering the pipe amplitude gate which was set about 50/sec late. Poor bond (probably perforating damage) is present only from 1550-1574 ft above the coated interval. The fracture is not well-defined on the fluid wave, possibly because it is right above the fluid contact.

BARE CASING WELLS

General

Four and one-half inch, 9.5-lb casing was set in a 7-7/8 in. hole on all wells logged. Perforating was done with an eight-way jet. All eight wells were fractured with 90,000 lb sand with fluid volumes ranging from 52,000 to 67,000 gal. lease crude. Tubing, pump and rods were run and the wells were placed on production. The rods, pump and tubing were pulled prior to running logs and rerun after logging.

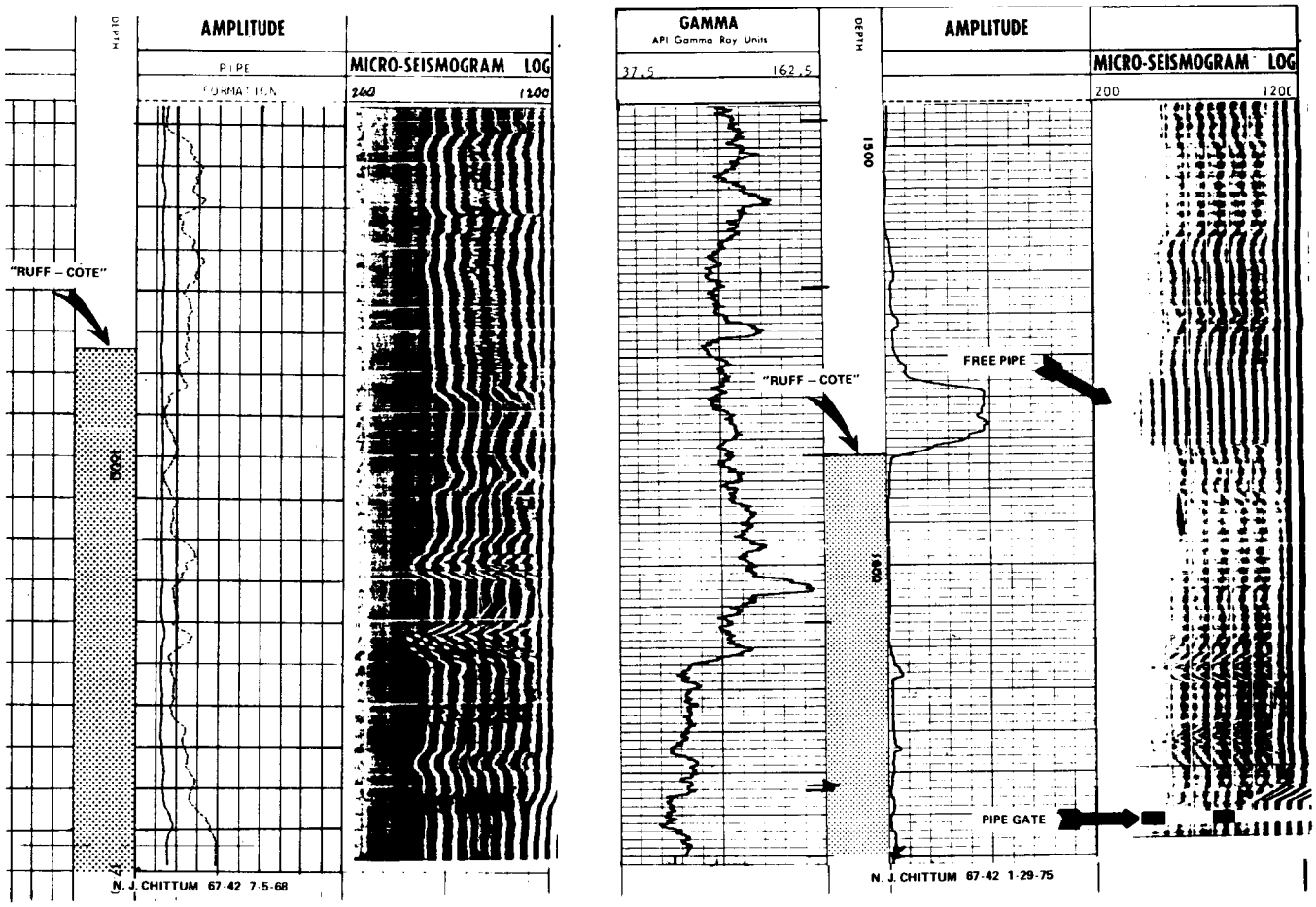

FIGURE 4

N. J. Chittim 67 - 3

The well was completed on November 6, 1959 with casing set at 1688 ft and cemented to the surface with common plus 2% gel. After perforating at 1633 ft, the well was fractured with a fluid volume of 60,000 gal.

A CBL (Fig. 5) run in the well on January 28, 1975 indicated poor bond-free pipe in the interval of interest (bottom three joints below the dashed line in the depth track). Mostly good bond was present above this section to 700 ft. It is believed that the poor bond is a result of perforating with the single-plane gun. The fracture could not be identified on the fluid wave due to poor bond opposite the perforations.

N. J. Chittim 67 - 4

The well was completed on November 10, 1959 with casing cemented to the surface from 1680 ft with common plus 2% gel. The perforations were at 1611 ft and fracturing fluid volume was 60,000 gal. lease crude.

This well was logged on January 28, 1975. The CBL (Fig. 6) shows poor bond in the interval from 1600-1616 ft. The MSG shows a possible split in the casing where the early multiple reflections show up opposite the perforations. Good bond exists above the interval of interest to 700 ft. The poor bond and possible casing damage are probably caused by perforating.

N. J. Chittim 69 - 4

This well was completed on July 29, 1960 at a total depth of 1750 ft. Perforations were at 1666 ft and fracturing fluid volume was 64,000 gal.

The CBL run on April 3, 1975 (Fig. 7) in 69-4

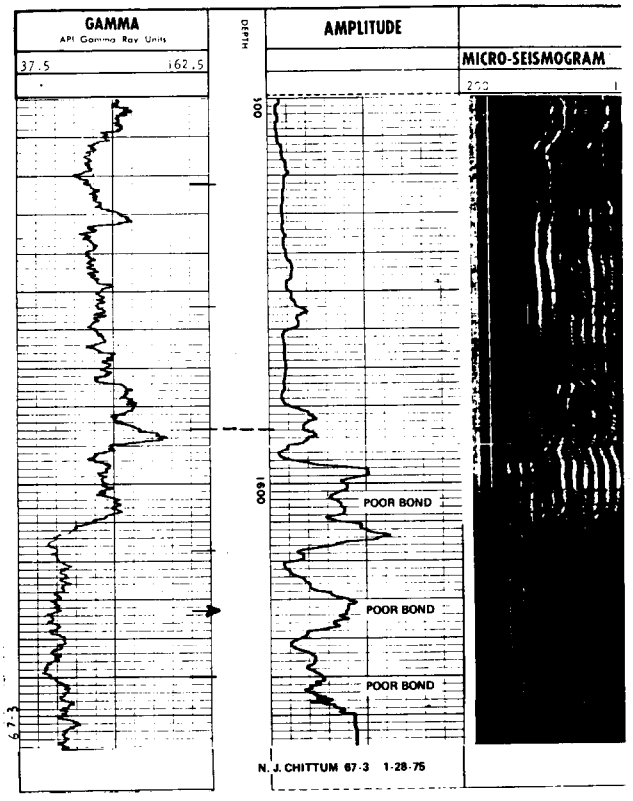

FIGURE 5

shows fair to poor bond in the interval of interest. This is the only section showing any probable damage to pipe cement bond in this well.

PERFORATING AND FRACTURING

In comparing the overall well conditions of all 16 test wells, the greatest difference, excluding the resin-sand coating versus bare-casing condition, was the perforating guns used. Since all of the bare-casing wells were perforated with an eight-way jet and all of the coated wells were perforated with a three-way jet, some question could arise to the effect that the eight-way gun inherently causes more cement bond damage than the three-way gun.

However, in comparing the two types of guns, it is found that the explosive charge in the three-way gun is 50% larger than that in the eight-way gun; i.e., 54 grams to 36 grams. Therefore, if cement bond damage is caused by expendable-type jet perforating guns, one would expect a greater degree of damage with the three-way jet. As the test results show no damage in the coated interval, this again is indicative of a stronger bond between the casing and cement.

Much of the damage to cement bond seen on these logs is probably due to perforating. Some extension of perforating damage may have occurred during fracturing operations. Figure 5 was an example of possible bond damage extension by fracturing. In other cases, such as shown by Fig. 4, fracturing probably had nothing to do with the deterioration of bond.

SUMMARY

None of the eight resin-sand coated wells showed any damage in the coated interval. Damage occurred above the coated interval in five of the eight wells.

Five of the eight wells completed with bare casing had damage to the cement bond in the bottom three-joint interval. This damage, attributed to the type of perforating guns used, and possibly fracturing operations, ranged from severely localized (possible casing split in 67-4) to moderate over a longer

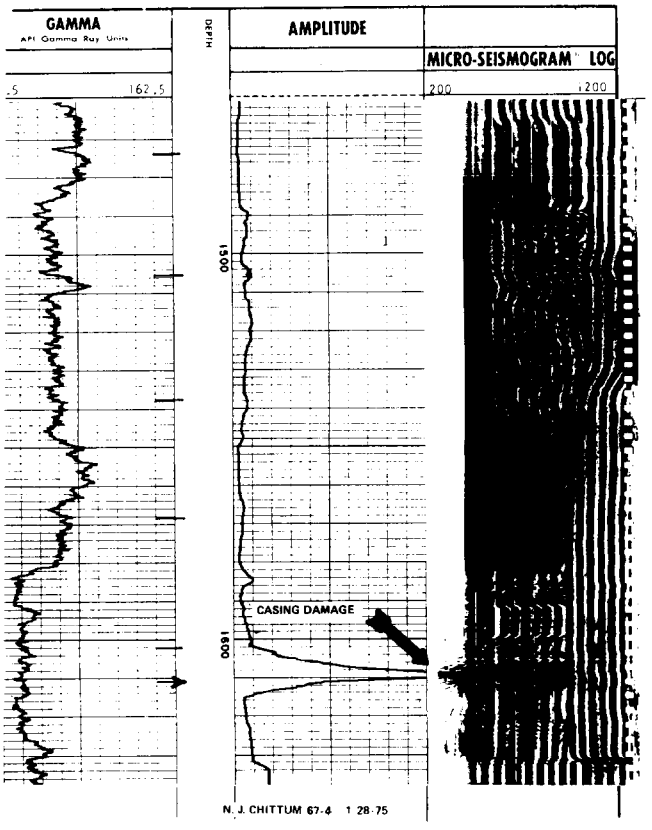

FIGURE 6

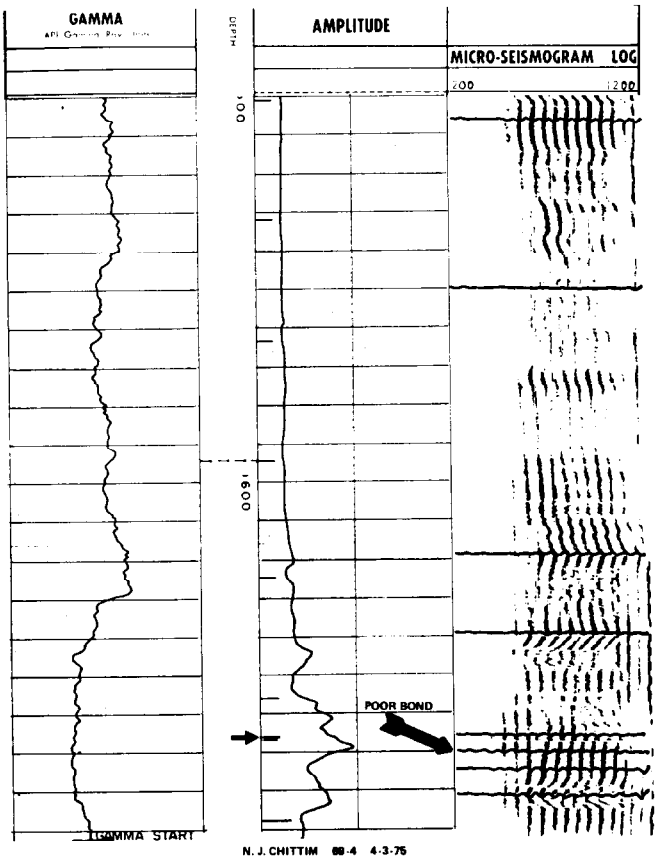

FIGURE 7

interval; e.g., 69-4. Ten of the 16 wells logged showed varying degrees of bond deterioration in bare casing. The six examples shown are generally representative of bonding conditions observed.

CONCLUSIONS

1. Resin-sand coated casing provided a better quality cement-to-casing bond over an extended period of time than normal mill-varnished casing.
2. Resin-sand coated casing withstood the shock from perforating operations better than mill-varnished casing.
3. Gamma ray log correlation of all wells did not show any communication behind the casing.
4. Fracture zones in those wells that had good bonding between casing-cement and cement-formation were well-defined on the VDL.
5. In the bottom three joints of casing, 60% of the wells without the "RUFF-COTE" process showed areas of poor bonding, whereas 100% of the wells with "RUFF-COTE" process showed excellent bonding.