PRODUCTION CHARACTERISTICS FROM 'WELLS DRILLED RECENTLY AT CERRO PRIETO GEOTHERMAL FIELD, MEXICO

J. DE DIOS OCAMPO DÍAZ[1] & J. DE LEON VIVAR[2]

'Universidad Autonoma de Baja California, B.C., Mexico
[2]Comisión Federal de Electicidad, B.C., México

SUMMARY

The Cerro Prieto geothermal field is the biggest and oldest geothermal area in step commercial production in Mexico. Exploitation of the geothermal field started in 1973, with 73 MWe of electrical capacity. Due to the present installed capacity of 720 MWe and the decline in steam production shown by some wells, it has been necessary to workover some wells and to drill additional wells to make up for the decline in steam production. Each year, about 11 to 12 wells are drilled, mainly in new reservoir zones such as the Cerro Prieto IV area. This paper presents the production characteristics observed at the wellhead, and wellbore conditions of the wells drilled recently in this geothermal field, obtained through output tests.

1. INTRODUCTION

Presently there are about 140 production wells supplying steam to four power plants with 720 MWe capacity in the Cerro Prieto geothermal field. These wells are located in four areas covering about 15 km^2, and are named Cerro Prieto I, Cerro Prieto II, Cerro Prieto III and Cerro Prieto IV (Figure 1). Some wells have been in production for 30 years. Monthly steam production fiom the wells is about 5600 tons per hour and 7500 tons of water per hour. In order to maintain the steam level required by the power plant, it is necessary to drill 12 new wells each year and to repair other wells.

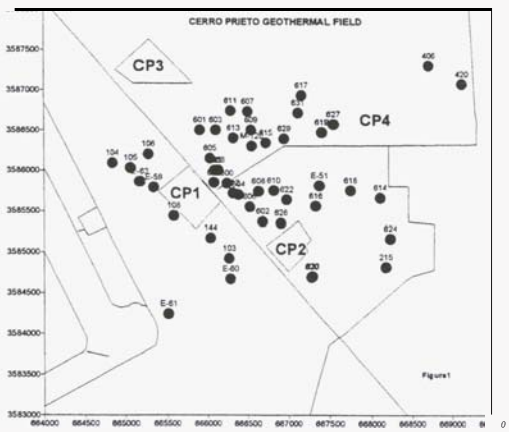

Figure 1 Cerro Prieto Geothermal Field

Production wells at the Cerro Prieto geothermal field have different reservoir conditions, such as single phase water, two-phase water, and in some cases, a dry steam phase (Lippman et. al., 1989, Beall et. al., 1997, Ocampo et. al., 1999). The geothermal fluids in Cerro Prieto move through altered sandstones cemented by small proportions of silica and calcite (Halfman et. al., 1986; Ocampo et. al., 1997). In the Cerro Prieto reservoir some processes such as boiling or dilution occur in the different reservoir zones. The geothermal fluid type is a sodium chloride, with a low concentration of bicarbonate and sulfate (Grant et. al., 1984; Truesdell et. al., 1997; Ocampo et al., 1999). The decline in steam production at the wells has been investigated, and attributed to four main causes: drawdown reservoir pressure, scaling in the bottomhole or main feed zones of the reservoir, scaling in any pipe section (casing production), and scaling that caused diameter changes in the orifice plate of the surface installation (Arellano et. al., 1995; Ocampo .et. al., 1998).

2. WELL DRILLING ACTIVITIES

To maintain the required rate of steam production, it is necessary to drill some new wells and to workover other wells that have a declining production rate. Table 1 shows some of the statistics for the 11 most recently drilled wells:

Well	Production interval (m)	Production Interval ϕ (in)
M-117A	2493.4-2893.4	7
E-37A	2487.0-2893.9	7
E-47a	2892.2-2492.8	7
E-35A	2397.9-2793.0	7
403	2592.3-2892.3	7
424	2284.5-2793.5	7
412	2395.5-2793.5	7
404	2488.6-2943.6	7
418	2522.9-2994.9	7
413	2492.2 –2892.2	7
406	2455.7-2760.7	7

The wells M-117A, E-37A, E-47A and E-35A are located in Cerro Prieto III area. These were drilled close to old wells that are no longer in production, but in the same platform. The average interval production thickness is about 802 m with slotted liner of 7 ϕ". The wells 403, 424, 412, 404, 418, 413 and 406 are located in Cerro Prieto IV area, the average interval production thickness is about 405 m with slotted liner of 7 ϕ". The total average depth of these eleven wells is around 2868 m.

3. DOWHOLE PRESSURE DATA

Before starting the output tests, downhole measurements were taken with the wells in a static condition (no flow). A mechanical pressure instrument (kuster) was used and the static pressure at the downholes is shown in Table 2. The well group of M-117A, E-37A, E-47A and E-35A recorded static pressures between 126.7 and 151 baras; the well group of 403, 424, 412, 404, 418, 413 and 406 recorded static pressures between 150 and 189 baras. The pressure values of these 11 wells are typical of a static water column and correspond to a reservoir dominated by a liquid phase.

Well	Static downhole pressure (bara)	Depth (m)
M-117A	151.0	2890.0
E-37A	145.3	2889.0
E-47A	128.6	2880.0
E-35A	126.7	2795.0
403	189.0	2900.0
424	150.0	2792.0
412	161.0	2800.0
404	173.3	2940.0
418	176.7	3000.0
413	166.0	2900.0
406	167.0	2760.0

4. OUTPUT TEST RESULTS

The following information shows the output test results only for the wells M-117A, E-37A, E-47A, and E-35A.

4.1 Well M-117A

Table 3 shows the output test results from well M-117A. In order to obtain the different production data the well was choked using different orifice plate diameters (2"ϕ to 3 ¼ "ϕ). Figure 2 shows the output curve (Mass flow rate against Wellhead pressure). Well M-117A was connected to a power plant with 39 WP and 71 t/h of steam flow rate. This well produces a two-phase flow.

Table 3 Output test data well M-117A

WP (bar_g)	Mass FlowRate (t/h)	Entalpia (kJ/kg)	Steam Flow Rate (t/h)
57.0	67.0	1964.0	39.0
51.0	93.0	1988.0	55.0
43.0	114.0	1977.0	67.0
41.0	124.0	1965.0	71.0
Production in line 28 January-2002			
39.0	127.0	2436.0	71.0

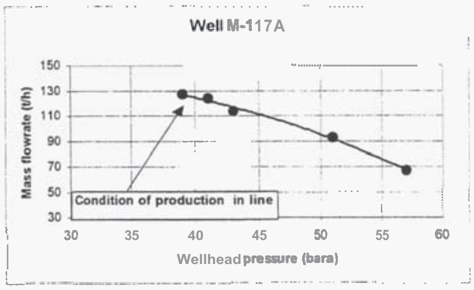

Figure 2 Output test data well M-117A

4.2 Well E-37A

Table 4 shows the output test results from well E-37A. In order to obtain the different production data the well was choked using different orifice plate diameter (1 ½" ϕ to 3 "ϕ). Figure 3 shows the output curve (Mass flow rate against Wellhead pressure). Well E-37A was connected to a power plant with 45.5 WP and 66.9 t/h of steam flow rate. This well produces a two-phase flow.

Table 4 Output test data well E-37A

WP (bar_g)	Mass Flow Rate (t/h)	Entalpía (kJ/kg)	Steam Flow Rate (t/h)
53.8	69.2	1347.0	18.6
54.5	82.7	1499.0	28.7
50.3	105.4	1648.0	44.5
Production in line 09-August-2001			
45.5	124.2	1884.0	66.9

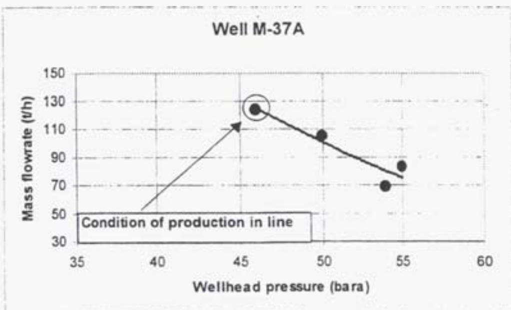

Figure 3 Output test data well M-37A

4.3 Well E-47A

Table 5 shows the output test results obtained from well E-47A. In order to obtain the different production data the well was choked using different orifice plate diameter (1 ½ "ϕ to 3 "ϕ). Figure 4 shows the output curve (Mass flow rate against Wellhead pressure). Well E-47A was connected to a power plant with 41.4 WP and 52.3 t/h of steam flow rate. This well produces a two-phase flow.

Table 5 Output test data well E-47A

WP (bar_g)	Mass Flow Rate (t/h)	Entalpía (kJ/kg)	Steam Flow Rate (t/h)
53.1	46.2	1943.0	26.4
50.3	59.1	1817.0	30.0
46.0	79.0	1822.0	40.4
41.0	106.5	1727.0	49.3
Production in line data 31-August-2001			
41.4	96.7	1888.0	52.3

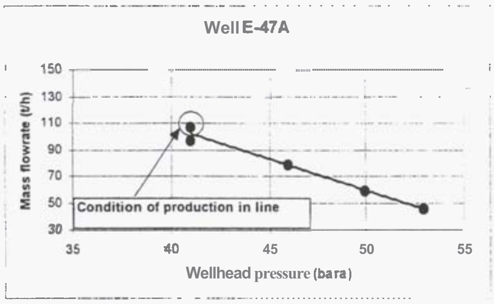

Figure 4 Output test data well E-47A

4.4 Well E-35A

Table 6 shows the output test results obtained from well E-35A. In order to obtain the different production data the well was choked using different orifice plate diameters (2 ¼ "ϕ to 3 "ϕ). Figure 5 shows the output curve (Mass flow rate against Wellhead pressure). Well E-35A was connected to a power plant with 45.2 WP and 68.8 t/h of steam flow rate. This well produces a two-phase flow.

WP (bar_g)	Mass Flow Rate (t/h)	Entalpia (kJ/kg)	Steam Flow Rate (t/h)
51.0	71.3	1607.0	28.7
49.7	85.2	1700.0	38.3
48.6	89.7	1710.0	40.7
44.8	111.9	1789.0	55.2
Production in line 17-November-2001			
45.2	136.9	1827.0	68.1

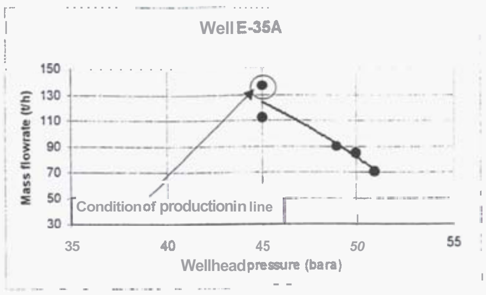

Figure 5 Output test data well E-35A

5. DISCUSSION AND FINAL REMARKS

As consequence of the natural decline in the steam production of the Cerro Prieto geothermal wells, every year it is necessary to drill and connect about 11 to 12 new wells to the power plant system. Some of these new wells are drilled in the same platform as old wells in Cerro Prieto III area; these wells have an average thickness production of 802 m. A group of new wells has been drilled in the easterly part of the Cerro Prieto IV field (the new reservoir zone in exploitation), and these have a production thickness of 405 m.

Together, these 11 recent wells show an average static downhole pressure of 158 bara. The output tests done in these wells used orifice plates of different diameters to control the geothermal flow discharge. All of the wells produce a two-phase flow (a mixture of steam and water).

6. REFERENCES

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