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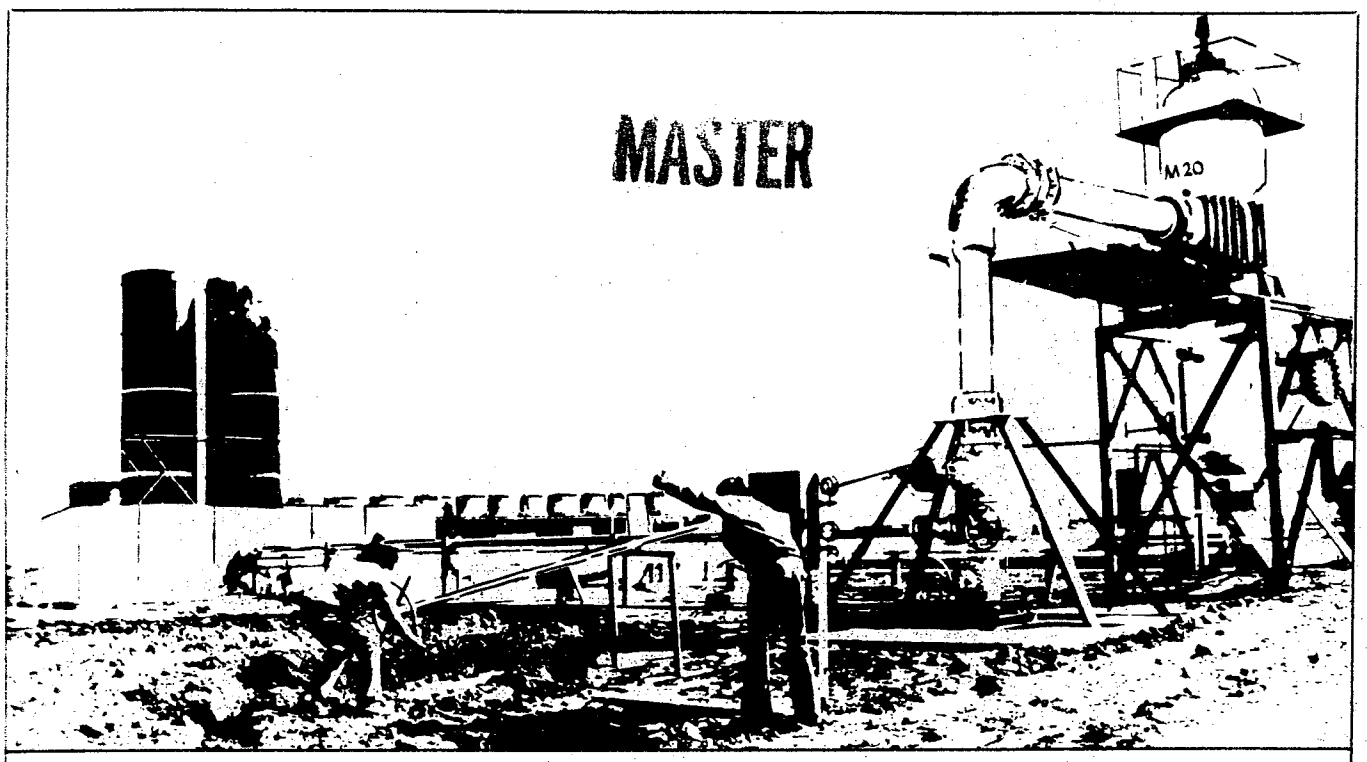
MEXICAN-AMERICAN COOPERATIVE PROGRAM AT THE CERRO PRIETO GEOTHERMAL FIELD



RECENT RESULTS OF THE WELL-DRILLING PROGRAM AT CERRO PRIETO

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RECENT RESULTS OF THE WELL-DRILLING PROGRAM AT CERRO PRIETO

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Abstract

The results of the 1980 and 1981 well drilling activities at the Cerro Prieto geothermal field are summarized. Details are given on the new series of deeper wells completed in the western ("older") part of the field (Cerro Prieto I), and on the development and step-out wells drilled in the eastern part of the field (Cerro Prieto II and III). Production characteristics of on-line and stand-by wells are discussed. Recent changes in well completion procedures are also described.

Introduction

During the last two years significant advances have been made in the development of the Cerro Prieto field. The purpose of this paper is to update the information presented during the Fifth Geothermal Reservoir Engineering Workshop (Alonso et al., 1979).

The installed electrical power capacity at the field continues to be 150 MW (four 37.5-MW high-pressure turbogenerators). A 30-MW lower-pressure unit has been undergoing testing since mid-1981. Before going into full operation, some installations of the flashing plant for this unit will have to be modified to improve its performance. At this plant, water at about 169°C separated from the high-pressure steam is flashed at 4.36 and 2.11 kg/cm^2 abs. The construction of two 220-MW power plants, each with two 110-MW turbogenerators, has begun. These plants are scheduled to go into operation during 1983 and 1984, respectively.

Drilling program

In November 1981 there were five drilling rigs and two work-over rigs active in the area; about 96 deep wells have been completed. Between December 1979 and November 1981 27 wells were drilled. These wells are shown in Figure 1, with the exception of well G-1, located about 6 km ENE of well NL-1. The total depths and maximum temperatures measured in these wells are given in Table 1.

TABLE 1

CERRO PRIETO
WELLS DRILLED BETWEEN DECEMBER 1979 AND NOVEMBER 1981
TOTAL DEPTHS AND MAXIMUM MEASURED TEMPERATURES

Well	Total Depth (m)	Max. Temp. (°C)	Well	Total Depth (m)	Max. Temp. (°C)
E-1	1996	338	M-115	under construction	
E-2	1945	328	M-117	2495	360
E-3	1814	333	M-118	2664	299
E-4	1767	333	M-122	under construction	
E-5	1966	322	M-125	2315	354
E-7	under construction		M-132	3268	284
G-1	3000	<100*	M-133	2356	310
H-2	3535	288	M-137	2506	>233
M-47	1730	>219	M-139	under construction	
M-73	1885	324	M-147	1908	353
M-79	1813	245	M-157	2545	331
M-109	2396	355	M-172	3287	282
			M-189	3495	267
			T-328	2695	349
			T-364	2926	320

NOTE:
* well filled with drilling mud

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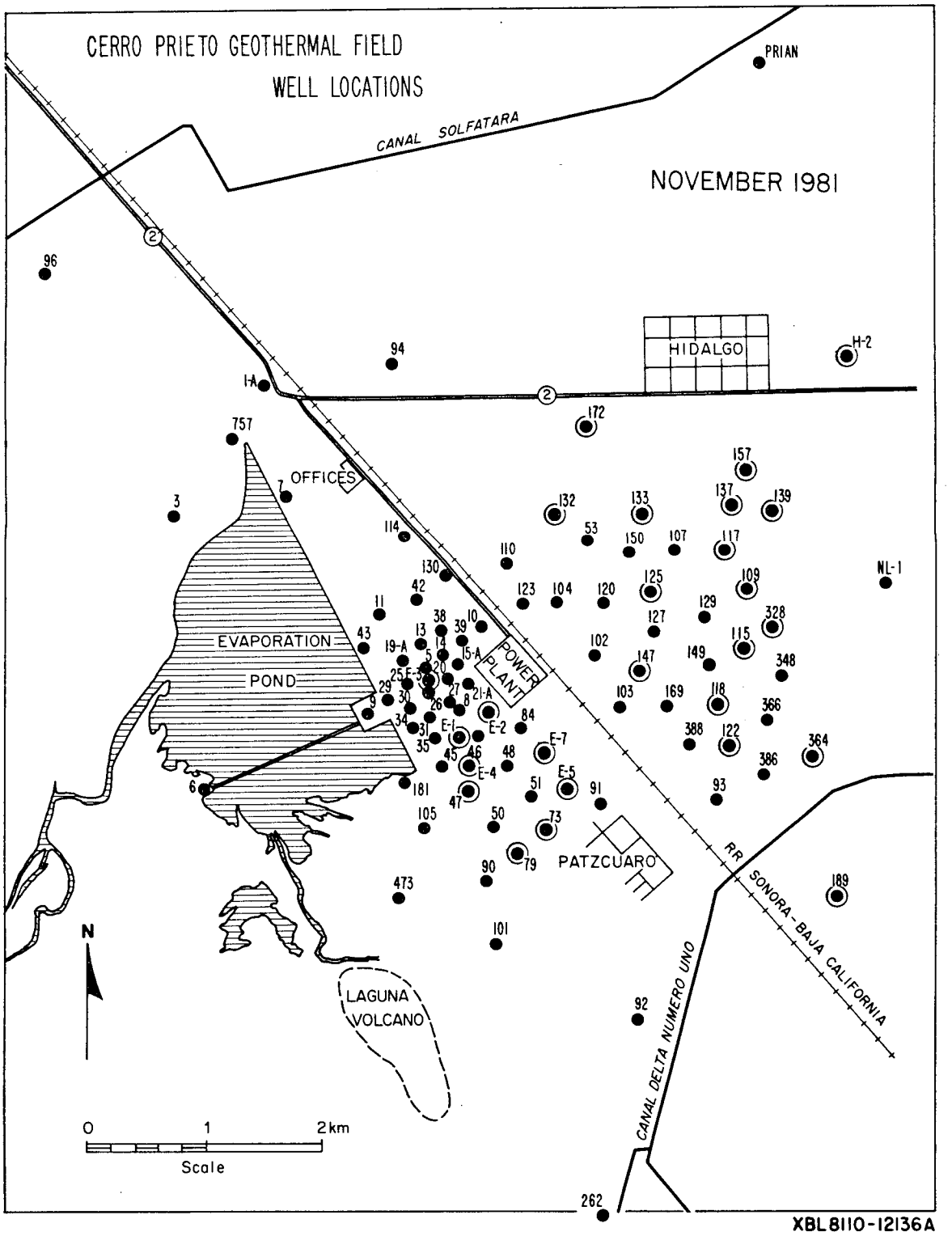

Figure 1. Location of wells at Cerro Prieto. Wells indicated with concentric circles were drilled between December 1979 and November 1981.

In the eastern part of the field the purpose of the drilling activity has been to increase the number of production wells for the power plants under construction, and to explore for the boundaries of the geothermal system. The temperature profiles obtained in the most recently drilled wells confirmed the temperature distributions developed earlier this year by Castillo et al. (1981) (See Figures 2 and 3). The wells drilled during 1980 and 1981 have essentially delineated the northern, eastern and southeastern boundaries of the thermal anomaly. Outside of this region, the 1977 Prian well (3496 m depth) and the recent G-1 well (3000 m depth) have shown very low temperatures.

In the western part of the field, new production and stand-by wells were drilled for the existing power plant. In that region the wells of the deeper "E-series" (average total depth: 1900 m) have confirmed the presence of a hotter aquifer (about 335°C) below the reservoir which has been under exploitation since 1973, and whose average temperature and depth are about 280°C and 1250 m, respectively.

Well pressures and production rates

Shut-in wellhead pressures in the northwestern part of the field (CP I Norte), excluding the E-wells, have reached up to about 800 psi; in the southwestern part (CP I Sur) about 900 psi; in the southeastern part (CP II) about 1300 psi; and in the northeastern region (CP III) about 1200 psi.

In CP I Norte (excluding the deeper E-wells) the maximum steam production ever measured in a well was 125 t/h. In CP I Sur, some wells reached 140 t/h of steam. In CP II, where the reservoir is at 2700-3000 m depth, steam productions of up to 300 t/h have been measured. In CP III, the reservoir is at 2000-2500 m depth, and some wells have produced above 100 t/h of steam. (Domínguez and Sánchez, 1981).

The production characteristics of the wells supplying steam to the power plant as of August 1981 are given in Table 2. At that time, the average electrical power generation

TABLE 2

CERRO PRIETO WELLS ON LINE
PRODUCTION CHARACTERISTICS
(AUGUST 1981)

Well	Orifice diam. (in)	Pressure (in psig) Wellhead	Separator	Production (metric tons/h) Steam	Brine	Enthalpy (cal/g)
M - 5	7 7/8	110	98	25.7	69.4	304
M - 11	4	119	104	13.5	47.9	281
M - 14	3 7/8	168	107	20.5	70.5	284
M - 19A	7 7/8	110	100	56.3	135.7	315
M - 25	4	240	112	38.5	73.1	344
M - 29	7 7/8	120	113	15.8	60.5	277
M - 30	7 7/8	110	100	41.4	106.1	309
M - 31	5	106	97	16.7	38.8	318
M - 35	7 7/8	122	105	53.8	130.1	316
M - 42	8	190	104	43.7	146.5	285
M - 43	8	108	107	18.7	54.0	300
M - 48	8	130	106	46.1	72.3	364
M - 50	8	125	108	75.4	167.8	326
M - 51	8	122	110	78.2	133.1	355
M - 53	8	124	103	17.3	25.2	370
M - 84	8	100	95	41.4	22.3	489
M - 90	8	108	106	41.4	129.0	292
M - 91	8	112	109.5	67.4	133.1	339
M - 101	8	104	102	17.6	27.9	361
M - 102	5	100	96	22.0	8.2	528
M - 103	4	185	104	48.5	48.3	418
M - 104	6	132	103	63.4	25.6	522
M - 105	8	130	115	56.1	81.6	375
M - 114	8	105	104	41.6	136.8	287
M - 130	8	115	107	53.3	131.8	315
E - 1	4 1/2	410	130	103.6	172.4	363
E - 2	3 1/8	872	131	64.4	108.7	361
E - 3	3 1/2	580	98	41.1	121.8	295
			TOTALS:	1223.4	2478.5	

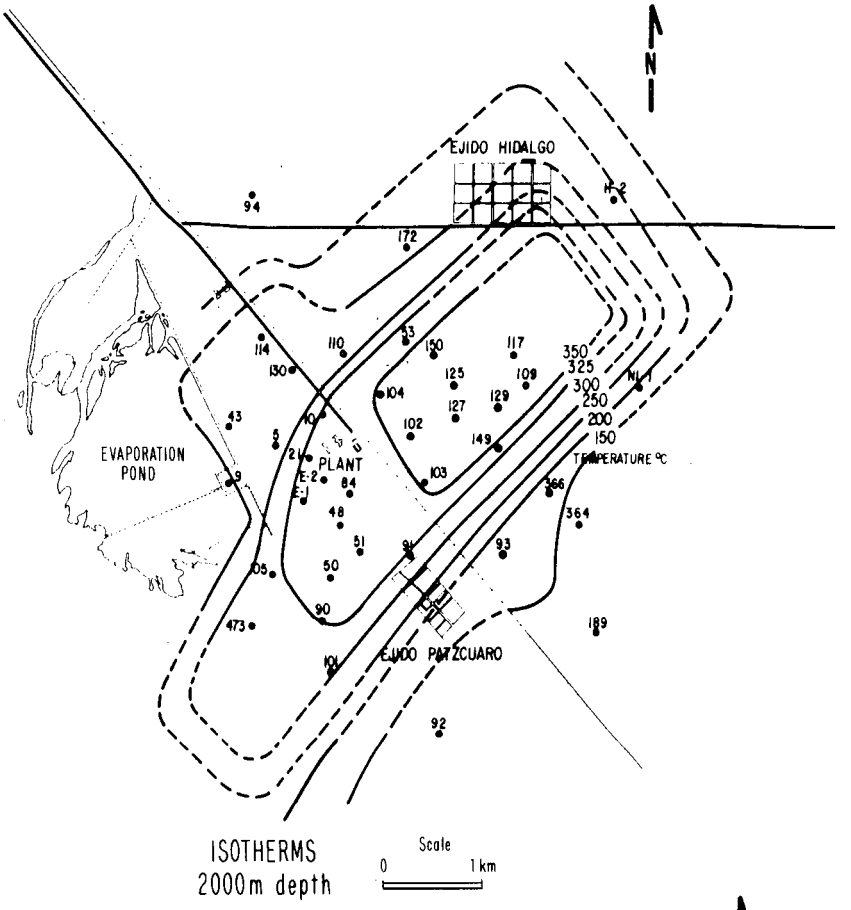

Figure 2.

Cerro Prieto; isotherms at 2000 m depth. (modified from Castillo et al., 1981)

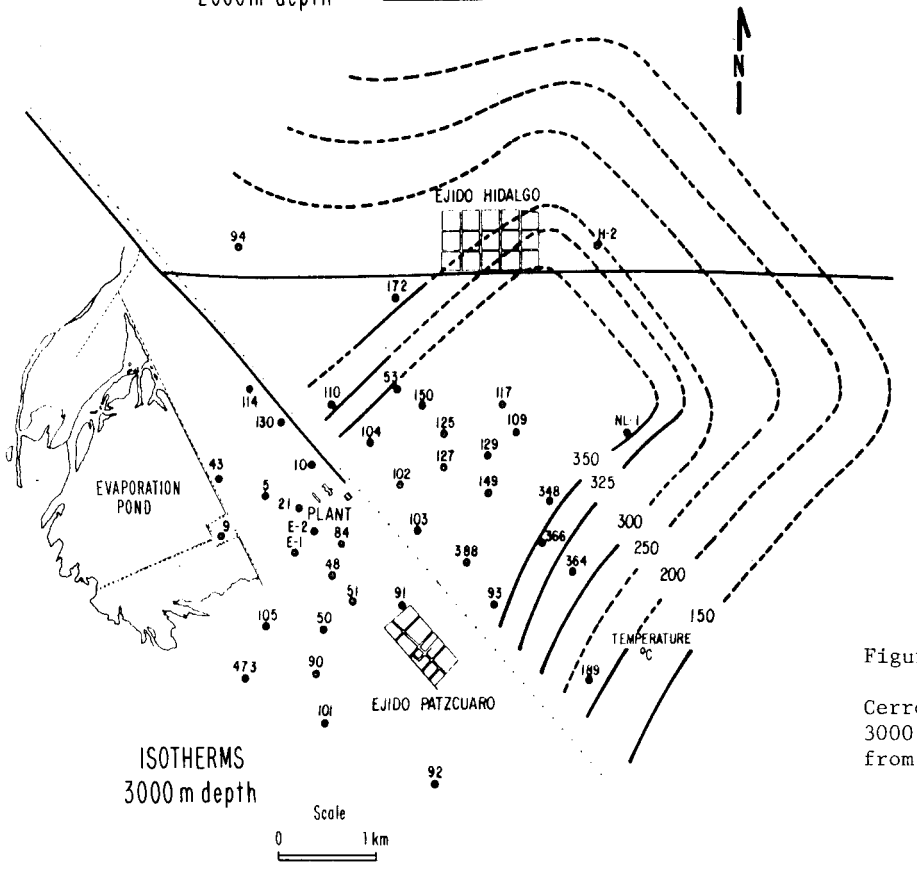

Figure 3.

Cerro Prieto; isotherms at 3000 m depth. (modified from Castillo et al., 1981)

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was 112.5 MW (only three of the four turbogenerators were on line because of repairs to one of the cooling towers). Table 3 shows the production characteristics of the stand-by wells.

Well completion

A number of modifications have been made in the way the wells are completed at Cerro Prieto, partly because deeper production and exploration wells are being drilled, and partly to reduce mechanical and corrosion problems in the casings (Table 4).

The casing completion described by Alonso et al. (1979, Table 2) using production casings with API N-80 tubing was not very successful. The lifetime of these casings is about 6 months (Domínguez et al., 1981). Corrosion, collapses and fractures have been detected.

Up-to-date results have shown that the wells completed during 1977-78 using API K-55 production casings have performed well. These heavier, soft steel casings have shown greater resistance to mechanical stresses and corrosion. The damages observed in some of the 1977-78 wells are believed to be related to faulty cementing of the casings caused by circulation losses and/or failure of casing accessories during the cementing operations.

Presently API C-75 grade production casings are being installed at Cerro Prieto (Table 4). Because of the recent installation, it has as yet not been possible to evaluate their performance.

To reduce circulation losses while cementing long strings of casings (up to 2000 m long), low-density cement slurries have been used. Recently, good results have been obtained by adding small diameter ceramic spherules to the slurry, reducing its specific gravity to about 1.3 (10.8 lb/gal).

In some wells, mainly because of circulation losses, none of the cement slurry returns to the surface. Recently, the non-cemented annular space behind casings has been filled by pouring fine silica sand. It not only reduces the open space behind the partially cemented casing, but also gives it mechanical support. Up to now the wells where this procedure was used have not shown problems.

Final remarks

The drilling of production and exploration wells will continue at Cerro Prieto. The immediate goal is to drill enough wells to satisfy the long-term steam requirements of the power plants. It is estimated that the existing plant will need 30 wells (6 MW/well), while each of the two power plants under construction will require the steam from about 25 wells (8.8 MW/well) to reach a total generating capacity of 620 MW_e by 1984.

In order to establish the areal extent and the energy potential of the southern parts of the field (CP I Sur and CP II) a number of wells are planned to be drilled soon in the area between wells M-101, 93, 189 and 92.

TABLE 3

CERRO PRIETO STAND-BY WELLS
PRODUCTION CHARACTERISTICS

Well	Date	Orifice diam. (in)	Wellhead Pressure (psig)	Production (metric tons/h) Steam	Water	Enthalpy (cal/g)
M - 7	7/25/79	5	100	15.0	101.5	235
M - 73	7/29/81	8	182	100.1	165.0	357
M - 93	6/22/79	8	170	80.7	186.0	320
M - 94	9/03/80	4	100	6.5	76.9	210
M - 110	11/18/79	10	220	185.3	335.7	346
M - 120	4/21/80	10	129	121.7	148.7	392
M - 129	2/12/80	5	700	216.0	301.2	376
M - 147	2/05/80	6	670	297.1	249.6	438
M - 149	3/02/80	8	104	66.4	124.8	342
M - 169	3/28/80	9	183	123.3	204.9	356
M - 172	9/09/81	6	101	23.3	117.3	253
T - 366	7/29/79	8	291	223.5	269.5	383
T - 386	10/07/81	10	110	86.0	159.5	343
T - 388	5/22/80	7	324	169.8	278.5	357
Q - 757	12/05/79	3	101	5.8	51.4	222

TABLE 4

CERRO PRIETO
PRESENT CASING COMPLETIONS

Casing	Size O.D. (in)	API Grade	Weight (lb/ft)	Joint Threads	Approximate Depth (m)
		PRODUCTION WELLS			
Conductor	30	B	98.9	Welded	0 - 50
Surface	20	J-55	106.5	RT.8T.SC.	0 - 300
Intermediate	13 3/8	K-55	68.0	BT.	0 - 1200
Production	9 5/8	C-75	47.0	SEU.HT.	0 - 2500
Liner	7	C-75	29.0	SEU.HT.	2450 - 3000
		EXPLORATION WELLS			
Conductor	20	H-40	94.0	RT.8T.SC.	0 - 100
Surface	13 3/8	K-55	54.5	BT.	0 - 500
Intermediate	9 5/8	C-75	47.0	SEU.HT.	0 - 1600
Production	7	C-75	29.0	SEU.HT.	1550 - 3300
Liner	4 1/2	C-75	13.5	CS.HT.	3250 - 3800

Notes
BT. = Buttress thread
RT.8T.SC. = Round thread, 8 threads/in, short joint
SEU.HT. = Super E.U. Hydrill thread
CS.HT. = C.S. Hydrill thread

Acknowledgments

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