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THE PERFORMANCE OF SEPARATION EQUIPMENT AT AHUACHAPAN GEOTHERMAL FIELD

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ABSTRACT

The measured steam quality variation of separated steam coming from the cyclone separators at Ahuachapān Geothermal field, during 10 years (1977-1988) has been annualized. Since the initial production time all the geothermal wells have had a fixed type of separator equipment designed for the characteristic values of the first production test. During the evolution of reservoir the output discharge of all wells has changed and the performance of the separators also change. These performance variations are analysed in order to verify the best separators basic desing theory.

INTRODUCTION

The production wells at Ahuachapān geothermal field and its mean production characteristics during the service period are showed on table I. For all the wells a tangential inlet cyclone separators were designed and installed, staying without changes for the entire wells production period. The data design of the two types of separators are summarized on Table 2. All dimensions are higher than the "Classic" dimensions calculated on the inlet mixture diameter (Bangma, 1961). The quality of separated steam was measured using the chemical method of Sodium (Na) relationship, (Awerbuch, Et al, 1982)like a control of separator performance.

Table 1. Mean Production Characteristics of Wells at Ahuachapān Geothermal Field.

WELL	PERIOD I 1977 - 1980 S.P	T.M	H	PERIOD II 1981 - 1984 S.P	T.M	H	PERIOD III 1985 - 1988 S.P	T.M	H
AH-1	0.64	85	985	0.61	66	942	0.60	55	942
AH-4	0.66	120	1151	0.68	60	1675	OUT OF PRODUCTION		
AH-6	0.64	40	1361	0.63	30	1884	0.60	20	1968
AH-7	0.62	53	1005	0.62	40	1005	0.60	40	1089
AH-20	0.63	54	1172	0.62	44	1361	0.60	40	1298
AH-21	0.66	105	1005	0.66	85	1047	0.63	80	1005
AH-22	0.60	60	1151	0.66	55	1047	0.64	30	1361
AH-23	OUT OF PRODUCTION			0.64	50	1130	0.65	32	1361
AH-24	0.60	52	1005	0.60	48	942	0.60	35	984
AH-26	0.64	25	1570	0.62	20	1570	0.60	18	1507
AH-27	OUT OF PRODUCTION			0.64	70	1151	0.60	61	1151
AH-28	OUT OF PRODUCTION			0.63	80	963	0.60	64	942

NOTES: S.P SEPARATION PRESSURE in Mpa.
T.M TOTAL MASS FLOW RATE in Kg/sec.
H DISCHARGE ENTHALPY in Kj/Kg

Table 2. Data design of Cyclone Separators at Ahuachapān Geothermal Field.

CHARACTERISTICS OF DESIGN		TYPE A	"CLASSIC" TYPE A	TYPE B	"CLASSIC" TYPE B
Nominal Capacity	T/H	350		550	
Mass of Mixture	T/H	360	360	565	565
Mass of Steam	T/H	60	60	95	95
Mass of Water	T/H	300	300	470	470
Inlet Quality	(%)	16.67		16.81	
Design Inlet volumetric Wetness	(%)	2.1		2.1	
Operating Pressure	(Kg/cm2g)	6÷7		6÷7	
Design Pressure	(Kg/cm2g)	17.5		17.5	
Body Inside Diameter	(mm)	1700		2100	
Height	(mm)	6950		8356	
Design separated steam quality	(%)	99.9		99.9	
Design pressure drop	(Kg/cm2g)	0.09		0.09	
Inlet mixture diameter	(mm)	508	508	609.6	609.6
Design inlet steam velocity	(m/s)	21.7		23.8	
Outlet Steam Diameter	(mm)	609.6	508	660.4	609.6
Outlet Water Diameter	(mm)	609.6	508	660.4	609.6
A Dimension	(mm)	3924	3556	4728	4267.2
B Dimension	(mm)	2574	2286	3128	2743.2
C Dimension	(mm)	2200	2032	2600	2438.4
D Dimension	(mm)	1700	1524	2100	1828.8
E Dimension	(mm)	1700	1524	1400	1828.8

REMARKS

"CLASSIC TYPE" :	Separators designed according with inlet mixture Diameter (Bangma, 1961)
A DIMENSION	From Inlet Mixture Center Line to the top
B DIMENSION	From Inlet Mixture Center Line to the bottom
C DIMENSION	From Inlet Mixture Center Line to the top of steam outlet pipe inside of cyclone
D DIMENSION	From Inlet Mixture Center Line to the water outlet Center Line
E DIMENSION	Cyclone Inside Diameter
TYPE B	Installed at AH-4 an AH-32
TYPE A	Installed at all remaining wells

BASIC THEORY

Bangma (1961) gave the base method for design geothermal separators establishing the nominal steam velocity at the inlet of the separators as the criterion for its performance and the recommended separator dimensions are given as a function of the diameter of the separator inlet pipe. If the well's output and separation pressure are known it will be possible to calculate the nominal steam inlet velocity for many sizes of separator inlet pipe. From the performance and pressure drop calculation the most suitable size of separator may then be determined. The volumetric wetness of the inlet mixture which afects performance and the pressure drop across the separator must also be taken into account.

B.R. White (1983) made an attempt to apply theory to the performance of "Wairakei" type of cyclone separators, reinterpretating all previosly published data with and emphasis on flow regime at the inlet and recomending more and new experimentation. The most desiderable separator operating conditions would occur in the slug and wave flow regimes for "spiral" inlet type and these regimes are associated with very low nominal carryover rates while annular flows have higher rates of water carryover.

Lazalde Crabtree (1984) gave the approach for designing steam water separators and steam dryers for geothermal applications but establishing that: there is no method that can be used for designin separation equipment which are also capable of predicting its behavior under several operating conditions; and The inlet steam velocity is a very important factor. At low velocities (less than 15 m/s), the outlet steam quality is bad and the equipment is big. Increasing the velocity , the outlet steam quality increases and pressure drop goes up, but the size of piping and equipment is reduced. Breakdown occurs at high inlet velocities (higher than 45 m/s) and becomes worse as the velocity in increased. The annular upward velocity inside the cyclone is also very important. At high values (higher than 4.5 m/s) the entrainment can be excessive.

DISCUSSION

Many of design methods were based on field experimentation using a basic designed separator tested on many wells with different output discharge values.

In practice it has been virtually impossible to obtain a compelte comparison of separating performances from one test to other, due to the fact that there is not posibility of control of the rating of steam to water in the mixture.

For a complete and exhaustive experiment it is necessary to have wells with a wide range of dicharge characteristics and several types of separator; then it could be convenient for investigation the performance variations of a fixed dimensions separator during the evolution of production characteristics on many wells.

The measured steam quality variations of some wells are showed on figures 1 to 10. It is possible to classify the results in four groups.

Group I : Strong variation (Wells Ah-4 and Ah-21)
Group II : Incremental variation from 20% to 100% (Wells AH-1 and AH-6).
Group III : Medium variation from 90% to 100% (Wells AH-24 and AH-1, And AH-6 at end of period).
Group IV : Small variation from 98% to 100% (Wells AH-7, AH-20, AH-22, AH-23, AH-26 AH-27 and AH-28)

The Group I results shows very low quality value and erratic fluctuations but operational problems (very high moisture content) had not been detected in early testing. This behavior could be produced by the orifice plate restriction that are installed in both wells downsteam of the master valve in order to reduce the mixture flow rate.

The incremental variation (Group II) shows increments on separated steam quality but this change is observed only in two wells (AH-1 and AH-6), This measured variation could be produced by changes on the sampling point or sampling method.

The Group III have a measured steam quality variations above 90% - but lower than the design point: 99.9% - meanwhile the Group IV have a quality measured higher than 98%. In both cases it can be observed a slight quality value declination at the end of the well production period.

CONCLUSIONS

1. The cyclone design based on the first well output can work with high quality separated steam for an adequate commercial period, even if there are total mass, and enthalpy variation.

2. The separated steam quality control by the Sodium (Na) relationship method can give results whith good accurancy for practical purposes.

3. The design method bases only on inlet steam velocity can be used for quality values, between 98% to 99%.

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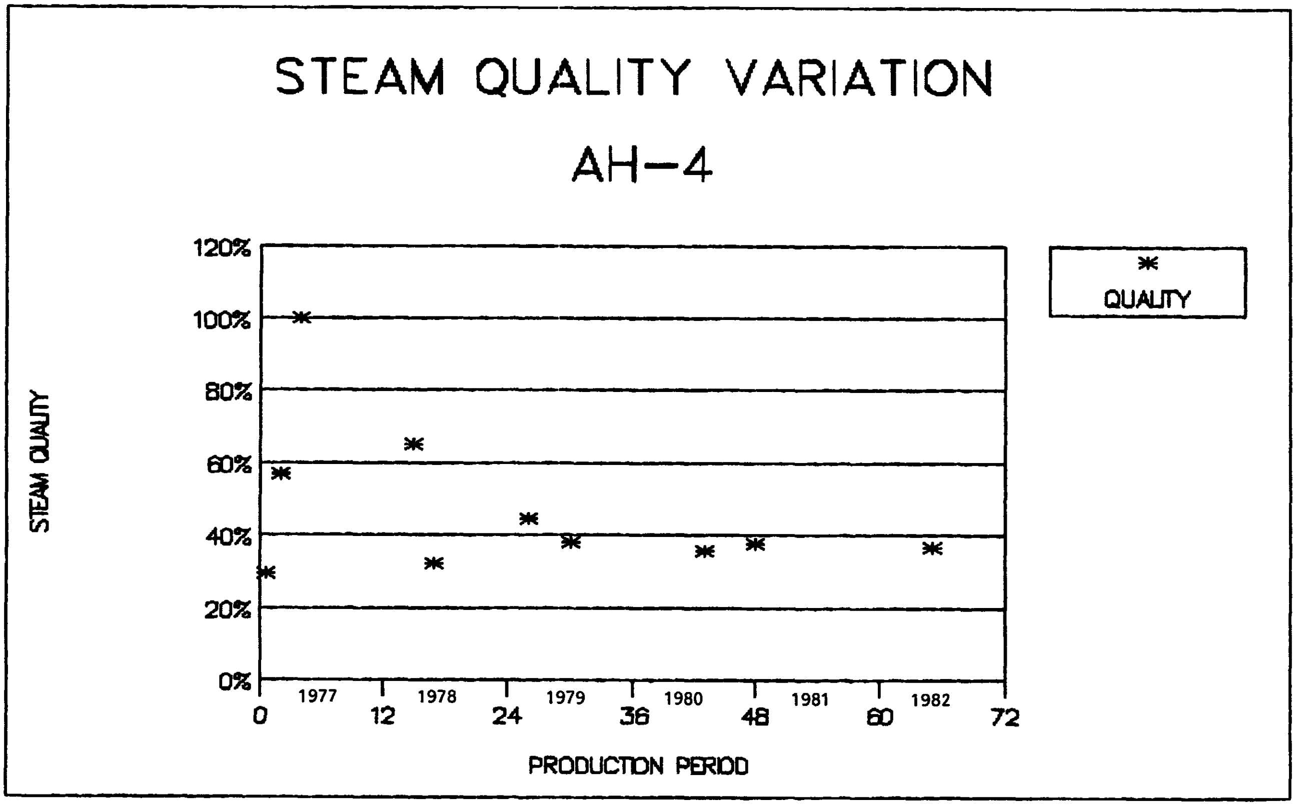

FIGURE 1 MEASURED STEAM QUALITY VARIATION OF AH-4 (GROUP I)

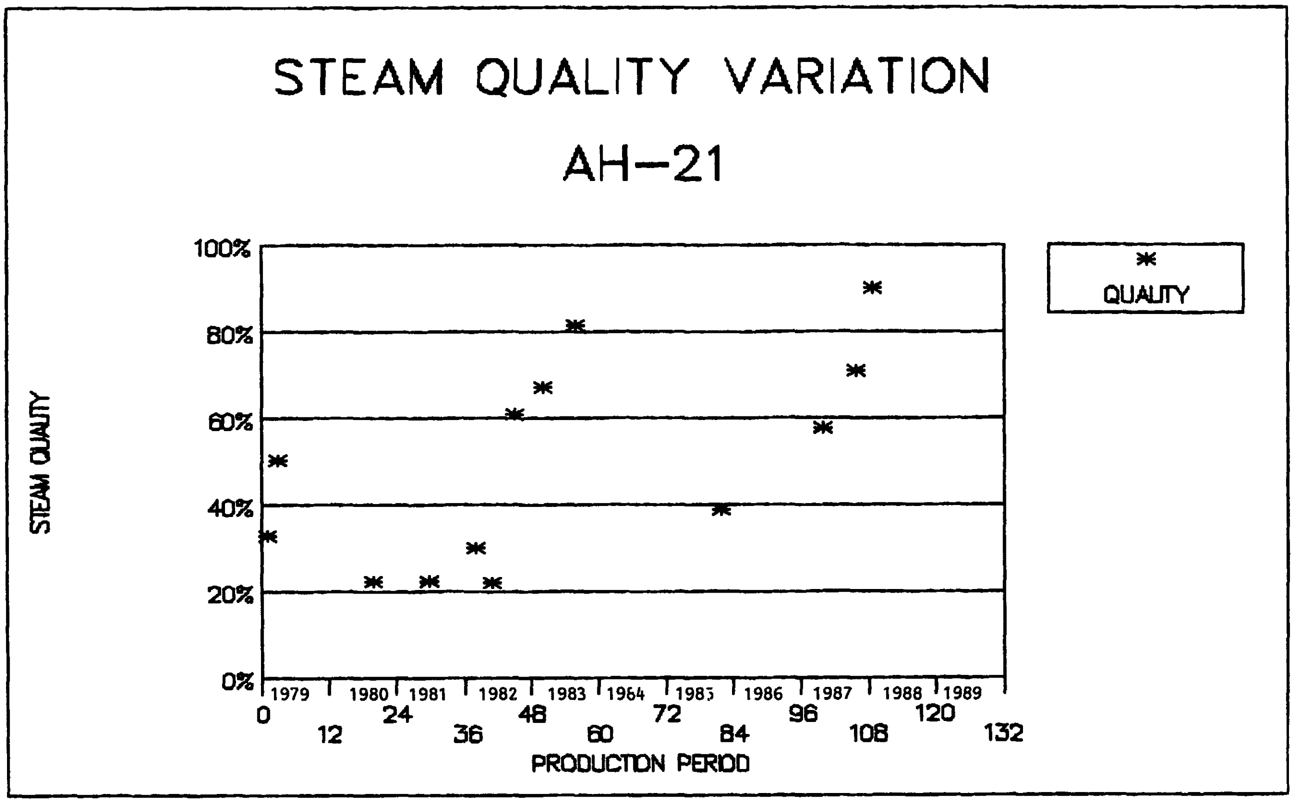

FIGURE 2 MEASURED STEAM QUALITY VARIATION OF AH-21 (GROUP I)

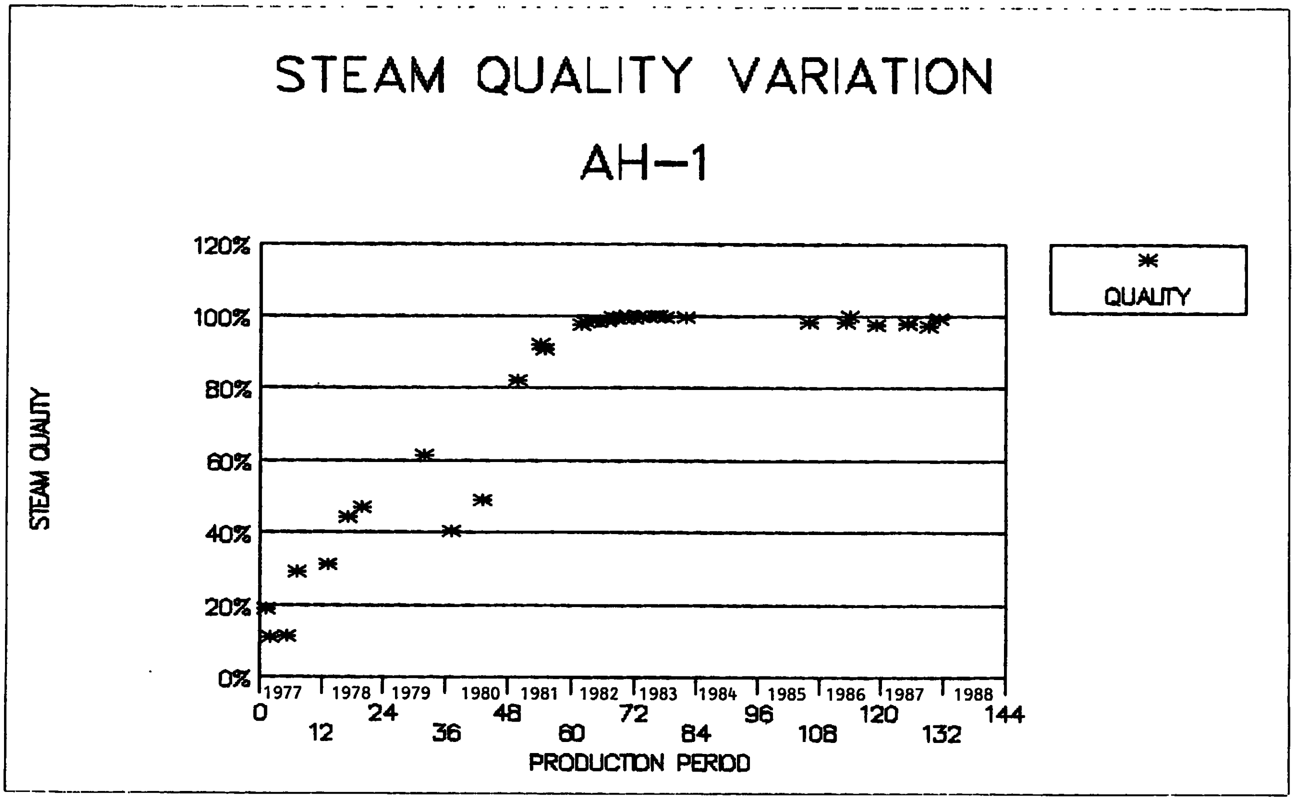

FIGURE 3 MEASURED STEAM QUALITY VARIATION OF AH-1 (GROUP II)

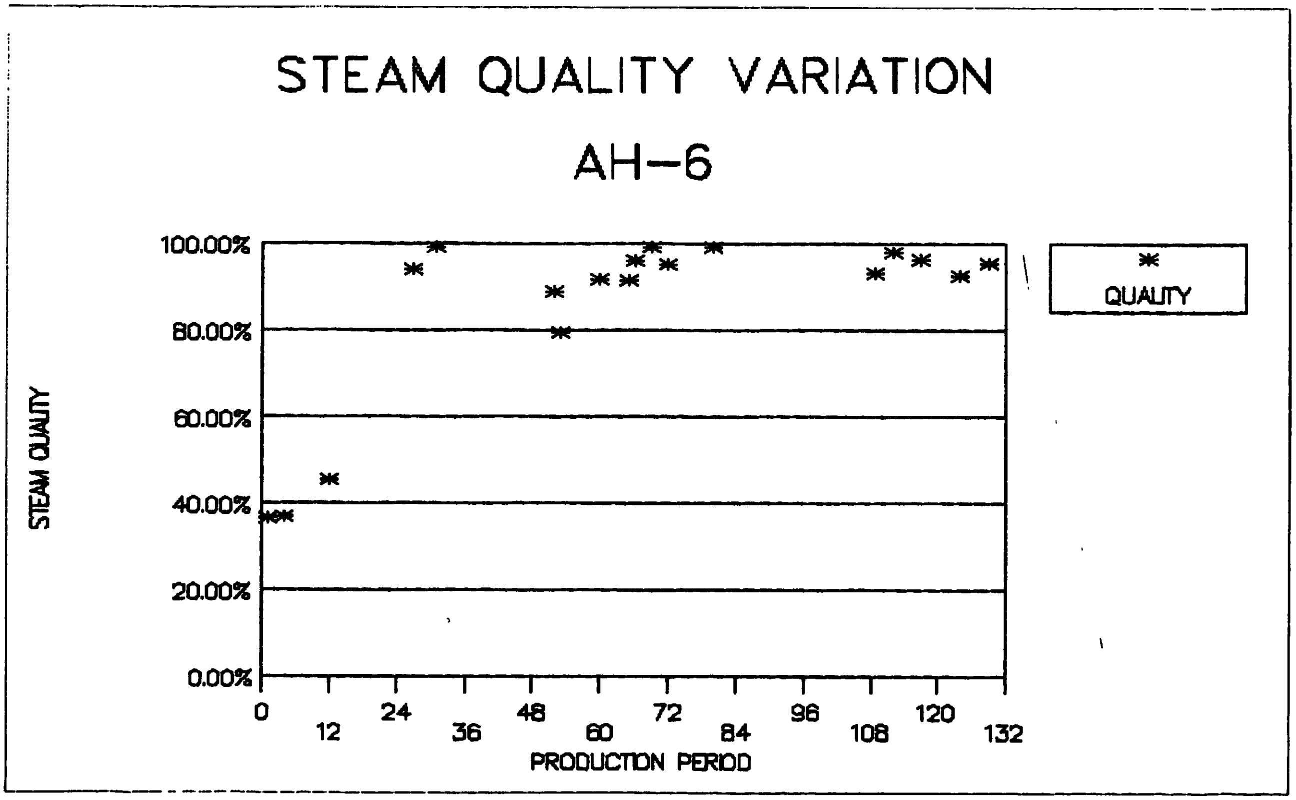

FIGURE 4 MEASURED STEAM QUALITY VARIATION OF AH-6 (GROUP II)

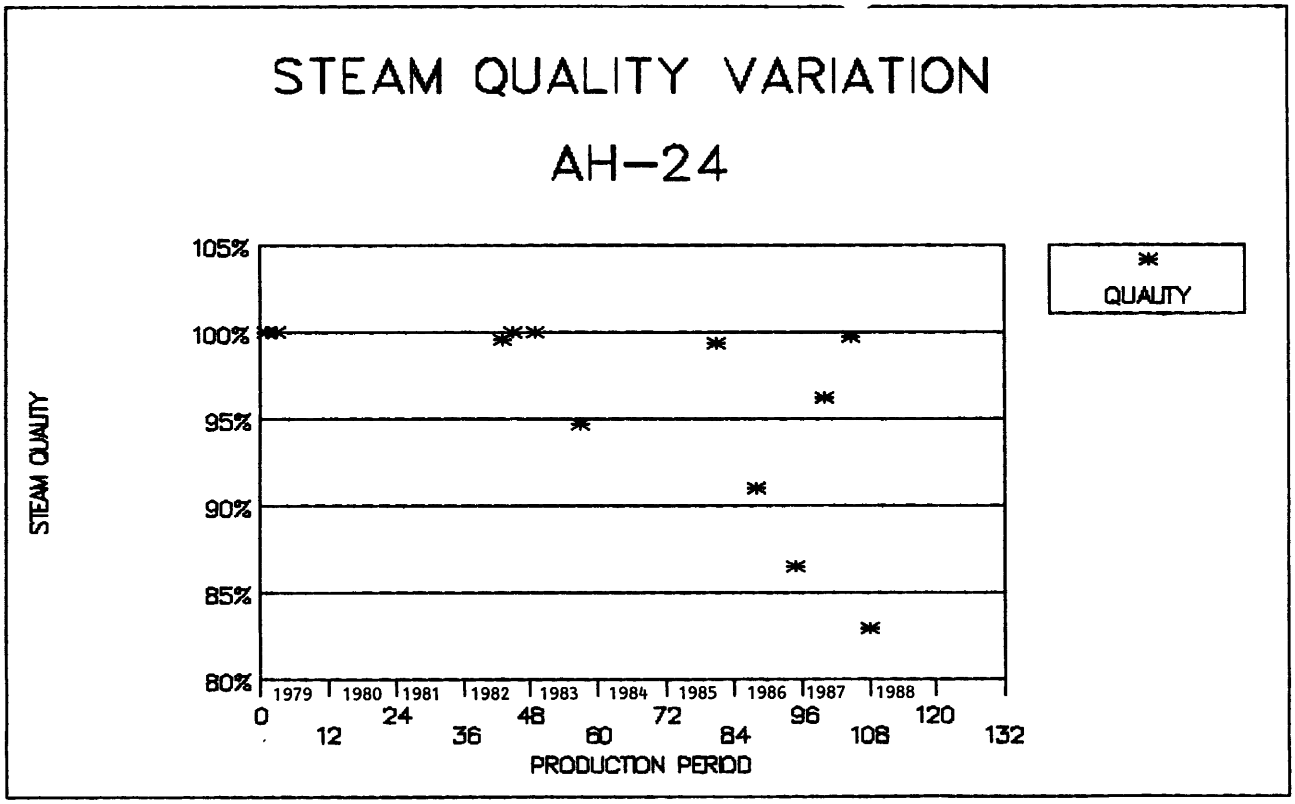

FIGURE 5 MEASURED STEAM QUALITY VARIATION OF AH-24 (GROUP III)

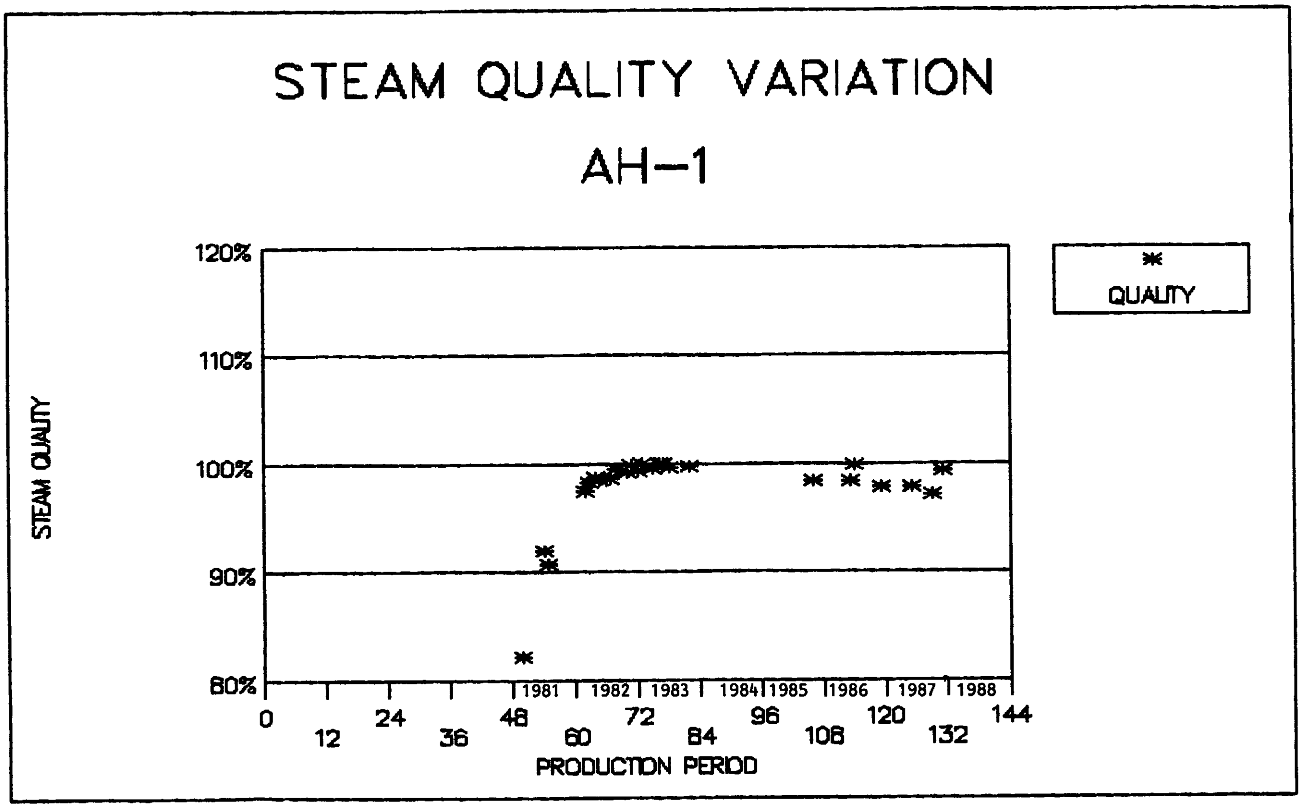

FIGURE 6 MEASURED STEAM QUALITY VARIATION OF AH-1 (GROUP III)

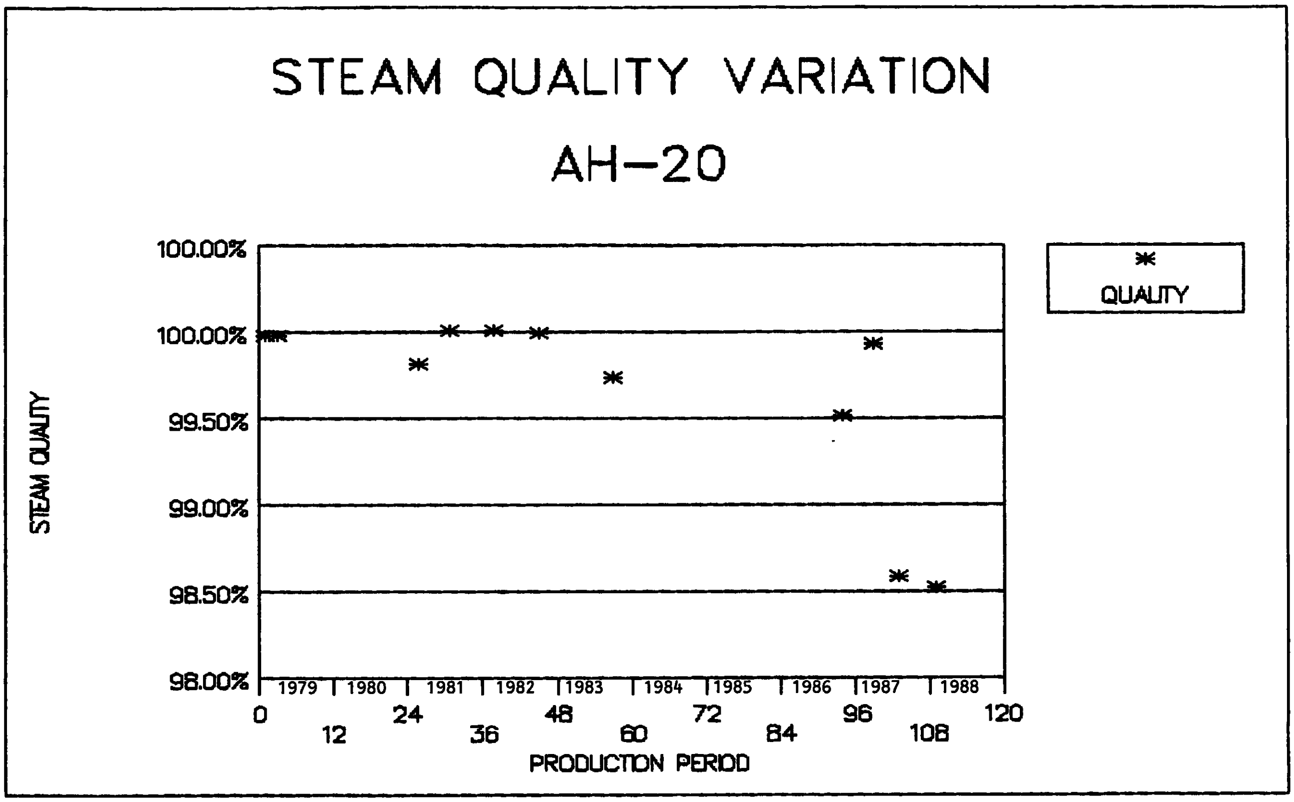

FIGURE 7 MEASURED STEAM QUALITY VARIATION OF AH-20 (GROUP IV)

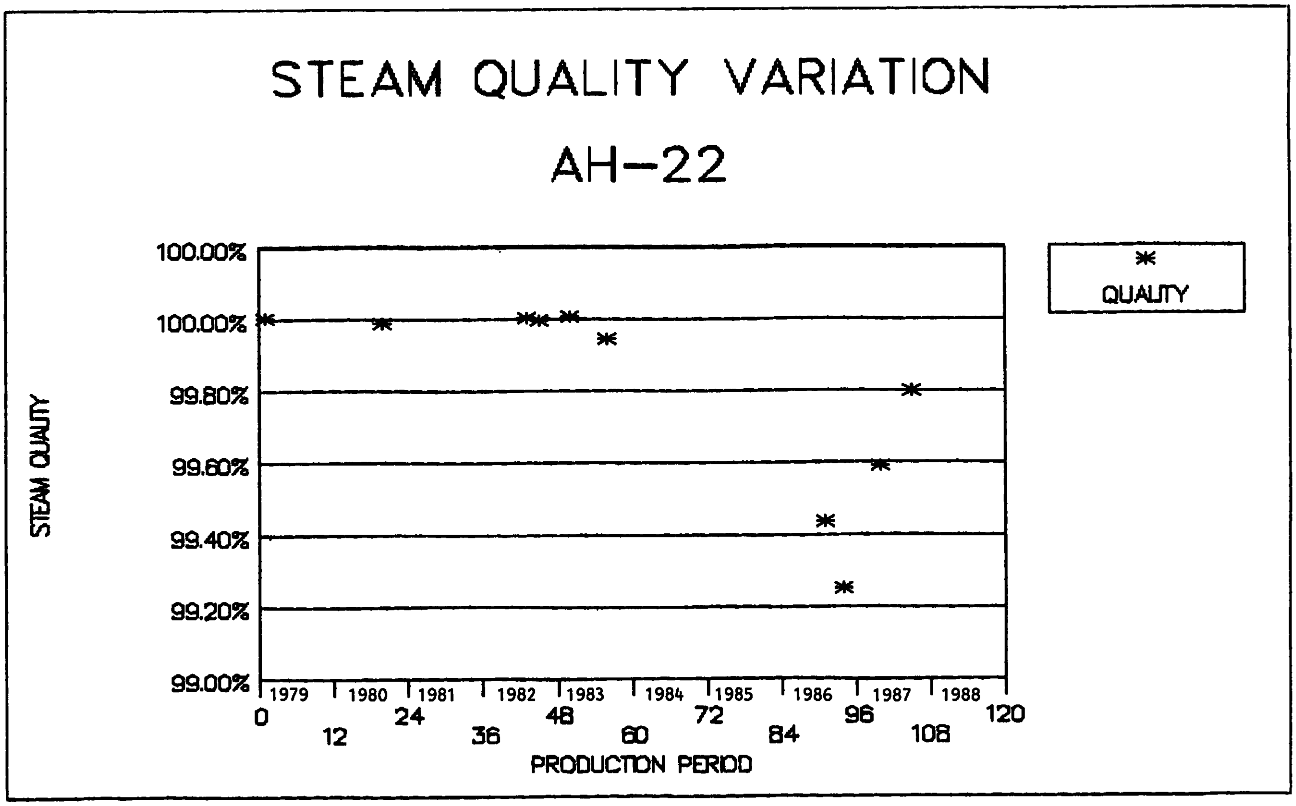

FIGURE 8 MEASURED STEAM QUALITY VARIATION OF AH-22 (GROUP IV)

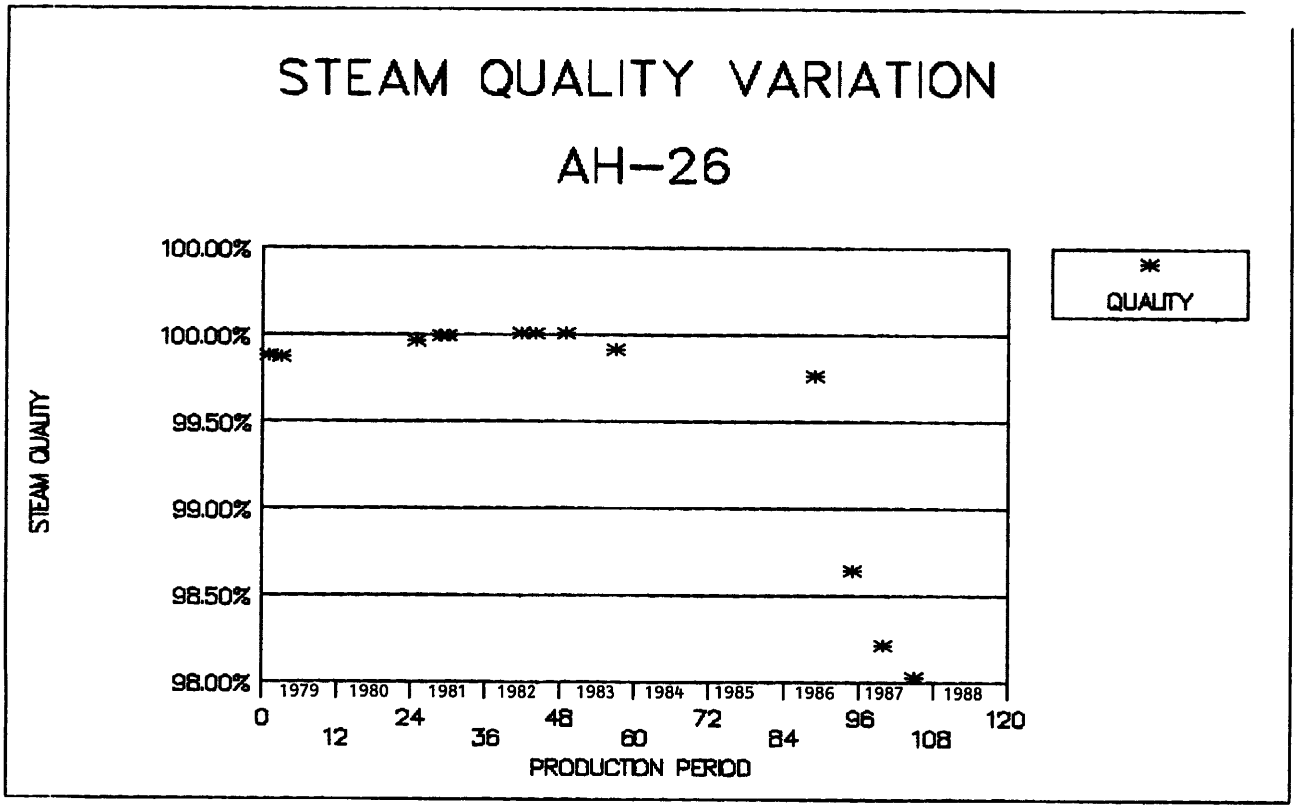

FIGURE 9 MEASURED STEAM QUALITY VARIATION OF AH-6 (GROUP IV)

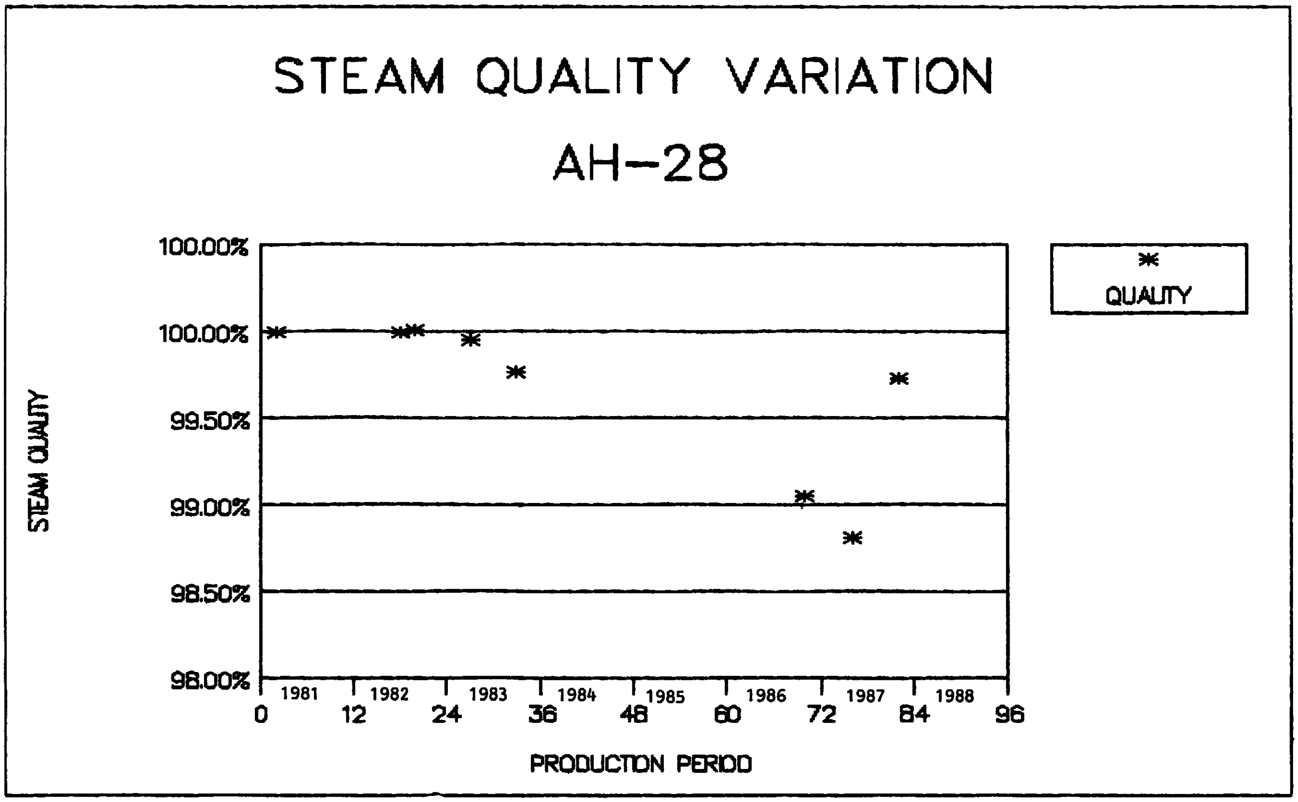

FIGURE 10 MEASURED STEAM QUALITY VARIATION OF AH-28 (GROUP IV)