Geothermal Resources Council, TRANSACTIONS Vol. 4, September 1980

A COMPACT INLINE SEPARATOR FOR SAMPLING LIQUID AND VAPOR FROM A 2-PHASE FLOWLINE

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ABSTRACT

A representative sample of vapor can be obtained in a 2-phase flow line by providing a space in which droplets of liquid are scarce. The material in that space can be sampled through a traveling probe and condenser setup, collecting condensate, non-condensable gases or both.

A counterpart space can be made also in which the liquid can accumulate essentially free of vapor. A sample can be taken through the same traveling probe apparatus as used for the vapor sample.

The method is an alternative to setting up a full-flow separator for early testing of a well when data on compositions of the separate phases are desired.

INTRODUCTION

Sampling fluids from pipelines carrying liquid and vapor is fraught with problems of representativity. Attempts to tap the flow stream and collect mixed vapor and liquid in proportion to their relative mass rates of flow are futile. Gradients of vapor/liquid ratios across vertical and horizontal directions of the cross-section are severe(1) and may change unpredictably. Steam separators for handling the full flow are available, but installation is expensive; and during early testing of a new well such separators may not be installed.

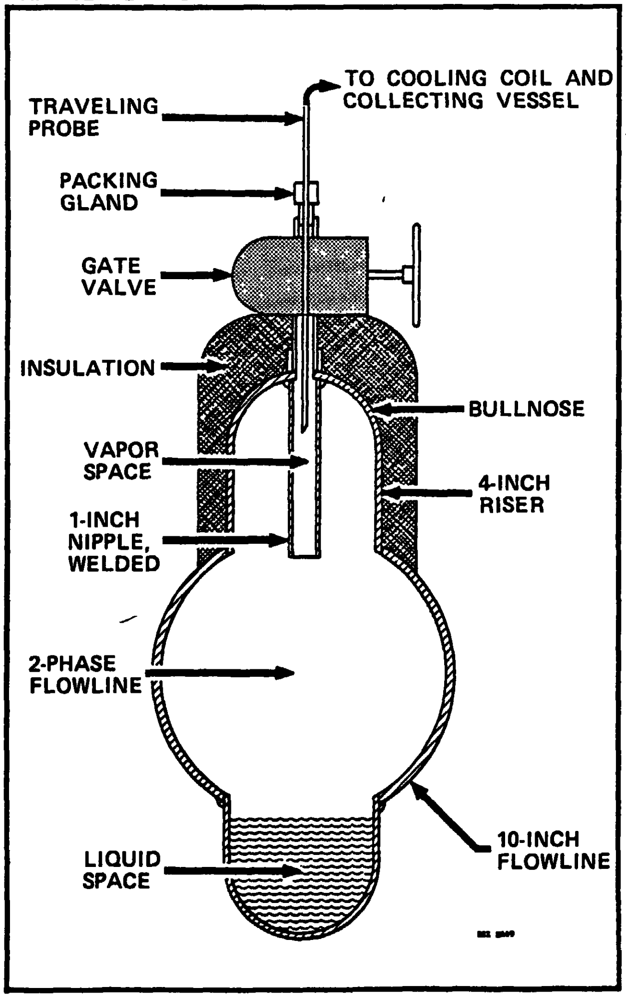
AN INLINE SEPARATOR

An alternative for the purposes of sampling to characterize the chemical nature of the liquid and vapor is available with a simple device shown in Fig 1. It can be built into the flow line on either side of the throttle valve, but preferably upstream. Taps for temperature and pressure measurements are important adjuncts. The device enables one to draw, from a 2-phase flow, a sample of vapor that is uncontaminated with liquid. Such samples can be used for analysis of noncondensable gases.

Inserting the probe all the way to the liquid zone at the bottom of the separator yields a brine phase sample. It can be passed through a cooling coil, to collect a sample which would represent the liquid that is in contact with the vapor sample. Alternatively, the liquid can be flashed to atmospheric pressure yielding a "fully-flashed liquid" which represents the geothermal resource in a somewhat different way.

Contruction of the device is described in Figure 1. The key item is a narrow space below the access valve in which liquid splash and droplets entrained in the vapor can be mostly

FIGURE 1
TRAVELING PROBE AND INLINE SEPARATOR

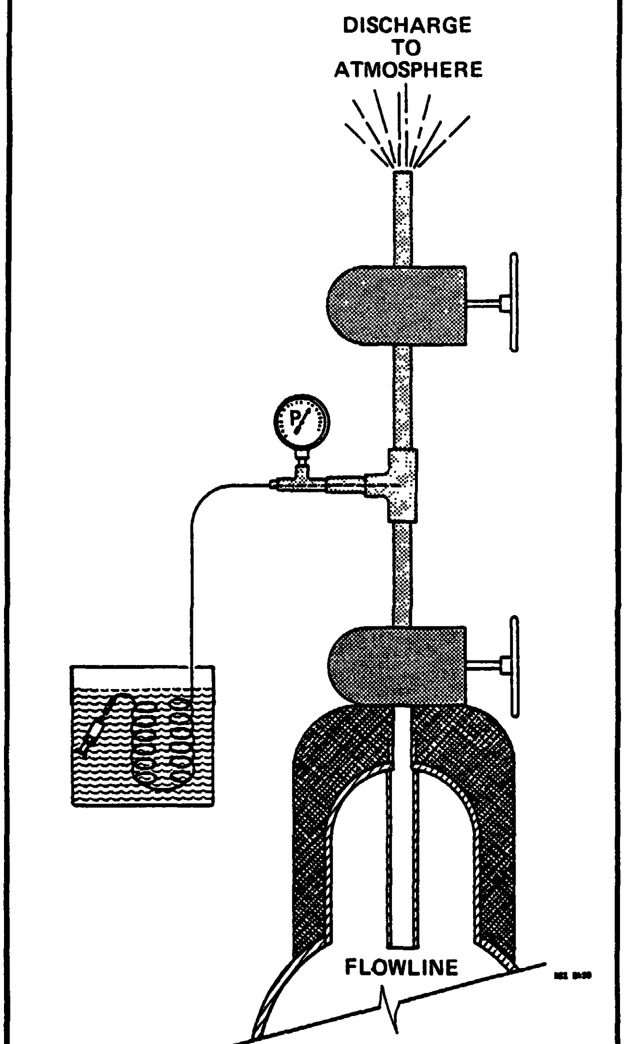


removed by contact with the walls. The vapor within this space is in chemical equilibrium, or at least a steady state, with respect to the liquid. It can be released to cooling coils and collection vessels by suitable valving arrangements on a probe assembly.

A prototype device was installed during a test of a deep wildcat well near the Niland KGRA this year. A sample of condensate obtained with this setup was analyzed for sodium and potassium in order to estimate liquid carry-over with the vapor. The carry-over was 0.6%, an amount small enough that the resulting bias to the non-condensable analysis was negligible. Temperature and pressure in the line during sampling were 407°F and 204 psig.

If the line pressure is too high for convenient collecting of a vapor sample the arrangment in Figure 2 is useful. Two valves are arranged to achieve a reduced pressure in the

FIGURE 2
PRESURE REDUCTION SETUP FOR STEAM AND NON-CONDENSABLE SAMPLING



DIAGRAMMATIC, NOT TO SCALE

steam path which can be tapped with a probe and the pressure measured with a gauge assembly. The sample collection apparatus shown diagramatically in Figure 2 refers to a system(2) for measuring non-condensables in a steam line. That method works well at 10 psig, a reduced pressure easily achieved with the suggested arrangement.

APPLICATION

The capability of measuring CO_2 in steam upstream of the throttle valve opens some useful options for evaluating the resource. Specifically, the percent flash appearing at the sample point can be varied by manipulating the throttle valve. Most of the CO_2 from the liquid is exhaled with the first 3 or 4% of flash. Thereafter, the differences in CO_2 content of the steam mainly reflect further dilution of the CO_2 with the new steam. To a good approximation, the percent of CO_2 in steam and percent flash are related in inverse proportion. By monitoring temperature, pressure and percent CO_2 one can track a segment of the relationship among them. The accuracy of the tracking is limited only by the accuracy of the three measurements and the stability of the CO_2 content in the liquid before flashing begins. This procedure is a variant of one proposed by W.A.J. Mahon in 1966 and reported also in (3).

It remains to relate the tracked portion of the relationship to the temperature of initial flashing and also to the full extent of flashing when the pressure is reduced to atmospheric. Details about both of those are outside the scope of this report, but brief mention of the possible measurements is worthwhile.

The temperature at initial flashing may be obtained by direct measurement at the wellhead, if the well is capable of delivering 1-phase liquid to that elevation. If not, then a wellbore survey of pressure-temperature made during active flow of the well will yield the basic data. The downhole temperature data should be downgraded to account for enthalpy losses between the position of flash initiation in the well and the reference position at the 2-phase sampler. Note that the empirical results from this 2-phase separator will yield thermodynamic data for the geothermal fluid that is self-compensated for the enthalpy losses between production zone and surface equipment. They should not be force-fit to simple models of temperature vs percent flash.

Relating the percent flash at the sampler to the percent flash at atmospheric pressure can be done through analysis of the brines collected at both places. Each should be force-cooled through a coil as part of the sampling procedure. To collect a brine sample from the inline separator the traveling probe arrangement used for the vapor sample is simply forced into the liquid-rich space. Brine flowed through the probe is cooled without allowing further flashing in order to obtain the requisite sample.

A fully-flashed brine sample also can be collected through the same probe simply by eliminating the cooling step.

Comparing the two samples is best done on a multicomponent basis. By plotting the results of one sample vs the other, a line may be fitted to the several concentration data. The slope of that line is proportional to the difference in flash represented by the two samples. This method yields more reliable estimates of flash between the two samples than can be obtained with single-component approaches.

SUMMARY

A device that involves about $100 worth of fittings and welding can be installed on geothermal flow lines as a steam/liquid separator for the purposes of sampling the flow. The device creates two new environments in the flow line, one predictably rich in vapor, the other rich in liquid. Each environment can be sampled separately with a traveling probe assembly.

The device is most useful when installed between a throttle valve and the wellhead. During a flow test operation, the samples collected from it can be used to deduce important thermodynamic properties of the geothermal fluid, since the non-condensable gases naturally present in the fluid are usable as a tracer in the steam fraction.

REFERENCES

(1) Riley, Wm. D. Oral report, "Advances in Sampling Technology" at Workshop on Scale Control in Geothermal Systems, Los Alamos, 17 April 80.

(2) Michels, D. E. "CO_2 in Geothermal Steam. A Rapid, Precise, and Accurate Field Assay Technique." Geothermal Resources Council Transactions, V. 2, p. 445-449, 1978.

(3) Ellis, A. J. and Mahon, W.A.J., Chemistry and Geothermal Systems: Academic Press, New York, p. 230, 1977.