Analysis Of Vapor Recovery Installations

By RALPH N. NELSON
Hy-Bon Engineering Co., Inc.

INTRODUCTION

A predominate question, "Why Vapor Recovery?" persists within the producing phase of the oil industry. The term has become rather generalized and may be misleading, exaggerated, or factual; however, whatever the condition it also justifies investigation. The present and future concern of all crude oil producers is efficiency in primary and secondary crude oil recovery; this phase has been effected with the trend of lease consolidation, unitization, comingling producing zones and centralized crude oil storage facilities. The primary purpose of this paper will be to evaluate at least 25 actual stock tank vapor recovery installations, factually compare similar results, and determine the basic requirements to properly evaluate the ordinary producing stock tank battery as a potential vapor recovery installation. The many applications, other than stock tanks, that lend themselves to installation of a standard vapor recovery unit will also be discussed.

APPLICATIONS

The applications available at a centralized stock tank battery have become too numerous to justify evaluation of the several approaches to an efficient treating, storage, and sales location of produced crude oil and by-products, "vapors". In order to attain 100% vapor loss recovery, sound engineering principles must be heeded and a positive approach made in design of the equipment; this has proven to be more evident as additional field experience is obtained. The following applications will be discussed to present a factual history of operations:

1. Stock Tank Vapor Recovery
2. Stripper Well Casing Pressure Control
3. Treating System Vapor Recovery
4. Crude Oil Gravity Stabilization.

ECONOMIC EVALUATION

Stock Tank Vapor Recovery System

The predominate application available for vapor recovery will generally be found at the standard stock tank installation as used for retention of crude oil and sales to a pipeline gathering system. The saleable product (vapor loss) and source of sale (gas sales line meter run) are found "on location"; this only requires a means of gathering and selling the product existing.

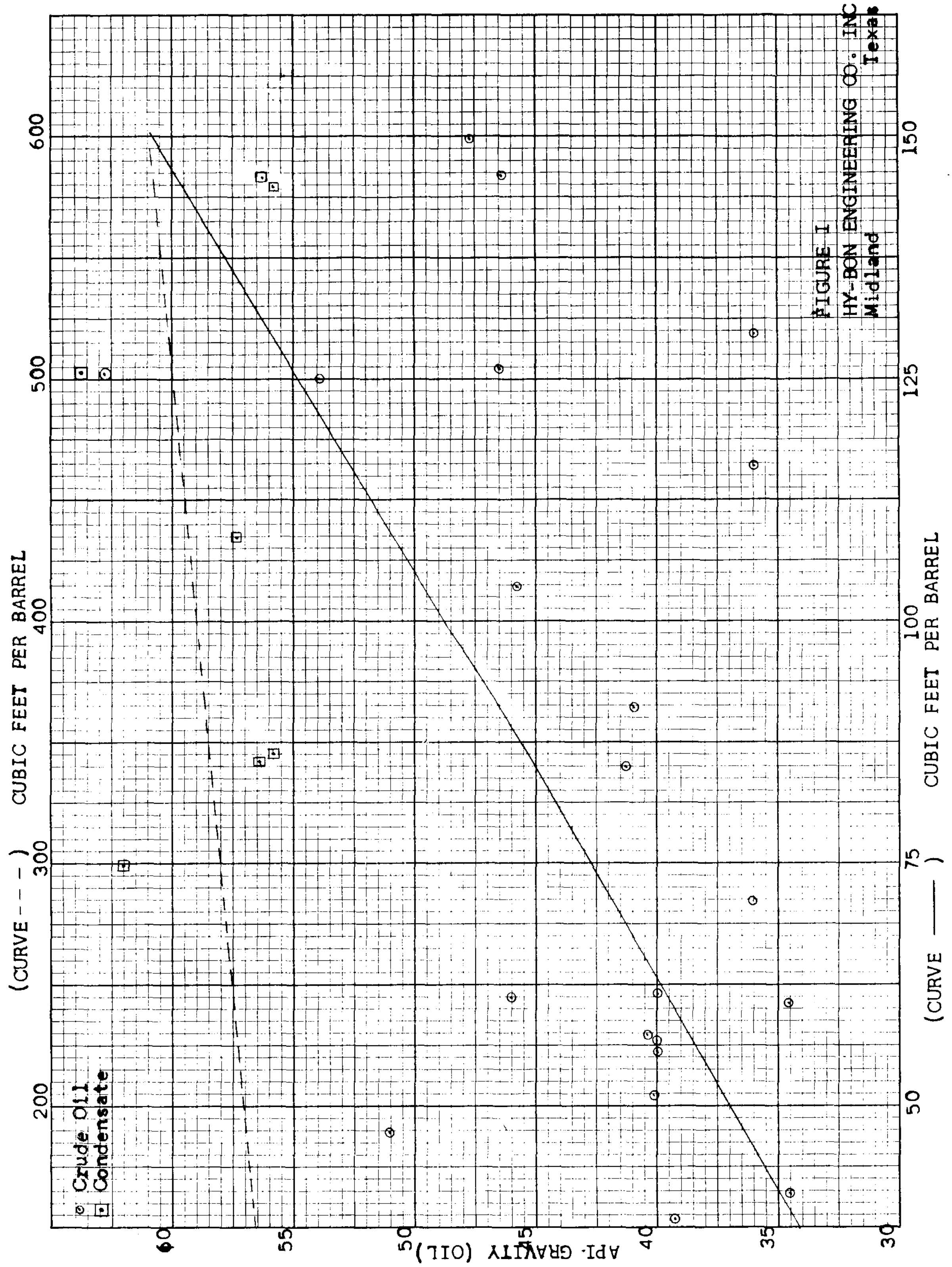
In order to evaluate an existing stock tank battery, the daily or monthly pipeline crude oil volume is readily available. This, of course, is after vapor loss; thus Figure 1 is compiled to indicate the resultant vapor loss (cu ft per bbl vs API pipeline gravity). The conditions prevailing to obtain Figure 1 were averaged with respect to treating pressure, treating temperature, configuration of fill lines, stock tank vapor pressure, July-January ambient temperature averages, retention time of crude oil, similar type treating systems, primary GOR, and similar equipment design; these factors can vary considerably, thus Figure 1 is intended to be relative and can be used as a guide. In order to illustrate the variable conditions found in stock tank GOR, Figure 1 illustrates the profound difference in GOR obtained from crude oil and gas condensate production; the largest change in gas condensate stock tank GOR was found in producing formations and primary GOR. The design volume for a stock tank vapor recovery installation can be partially obtained by conventional metering methods or factually obtained with a rental test unit; we have determined through experience certain factors should be applied for the respective method of measurement.

Determination of the maximum tank vapor volume, withstanding future changes in flow rates, will assist in obtaining the installation costs for a specific application. Figure 2 illustrates the total installation cost versus MSCFD compressed to 40 psia. The installation costs have been obtained from conditions where primary power supply is available on location, contract labor used for installation, standard tank battery piping and tanks, normal vapor pressure conditions prevailing, standard design vapor recovery components used in accordance with API recommended standards. Figure 2 is compiled as a result of investigating actual stock tank vapor recovery installations for different operators and averaging the cost per MSCFD installed; it is presented to be used as an estimation of an actual installation subject to revision if so required by circumstances.

Figure 3 is compiled to illustrate the sales price of stock tank vapor obtained from actual installations. The actual value of stock tank vapor will accordingly change with casing head gas contracts for the specific lease. It is felt that by indicating the return to lease for each installation an average estimate can be obtained for most gas sales contracts. The dotted line will indicate the relative liquid product sale price of corresponding 115° API crude oil based on $2.94 per bbl; this condition would indicate the value of gpm if sold on this basis.

Well Casing Pressure Control

During the current economic condition of crude oil production proration, the productivity of marginal pumping wells has become a source of investigation. Several factors have normally caused the specific well to become classified a marginal; thus this paper will only be concerned with the problem of casing pressure vs production rate. The current trend of lease consolidation has effectively increased the casing pressure of pumping wells primarily because of the greater length of flow lines and treating system pressure increase;



(CURVE - - -) CUBIC FEET PER BARREL
200
300
400
500
600
(CURVE ——) CUBIC FEET PER BARREL
50
75
100
125
150
API. GRAVITY (OIL)
60
55
50
45
40
35
30
Crude Oil
Condensate
FIGURE I
HY-BON ENGINEERING CO. INC.
Midland Texas

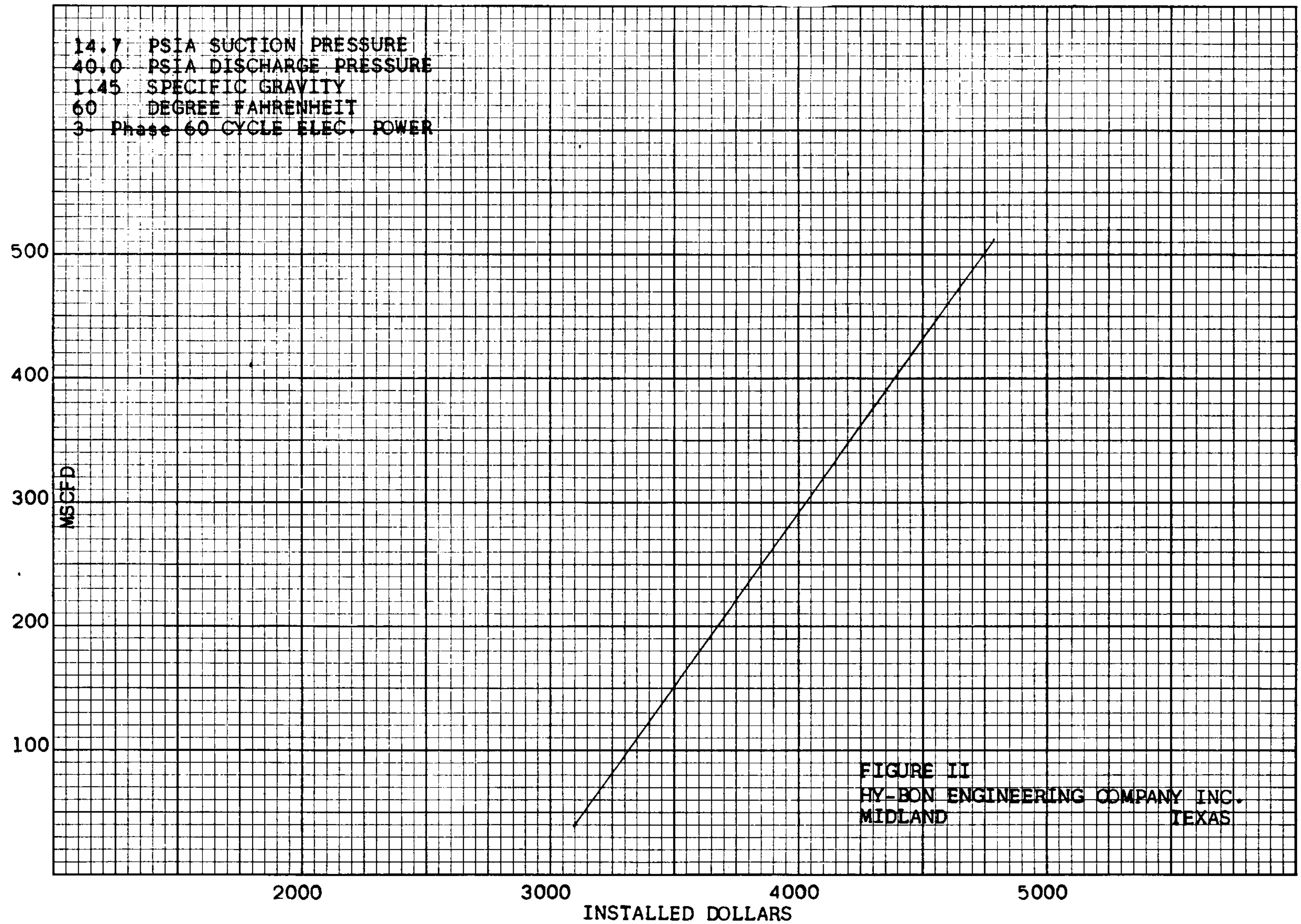


FIGURE II
HY-BON ENGINEERING COMPANY INC.
MIDLAND TEXAS

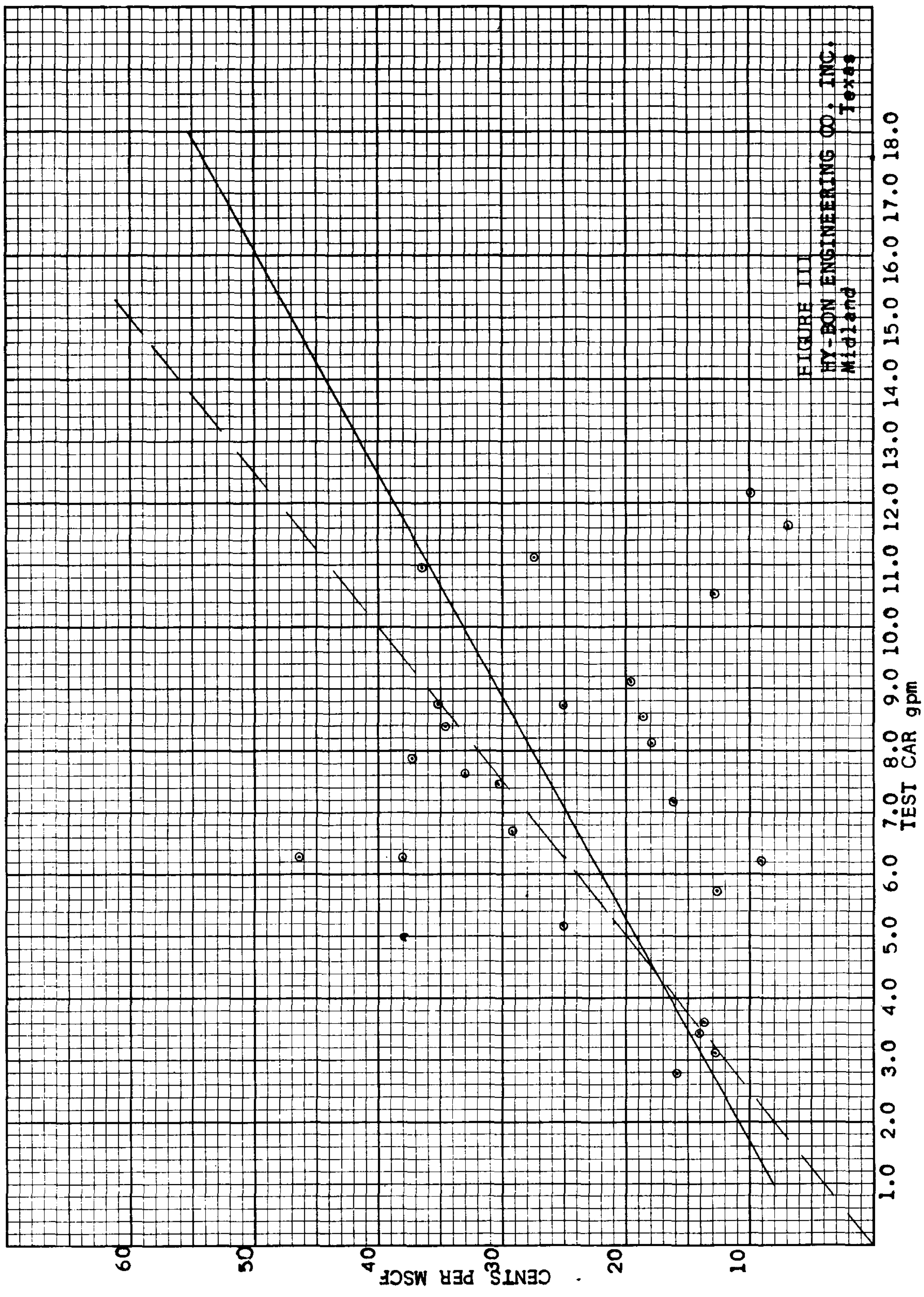


FIGURE III
HY-BON ENGINEERING CO. INC.
Midland Texas
1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0 11.0 12.0 13.0 14.0 15.0 16.0 17.0 18.0
TEST CAR gpm
10 20 30 40 50 60
CENTS PER MSCF

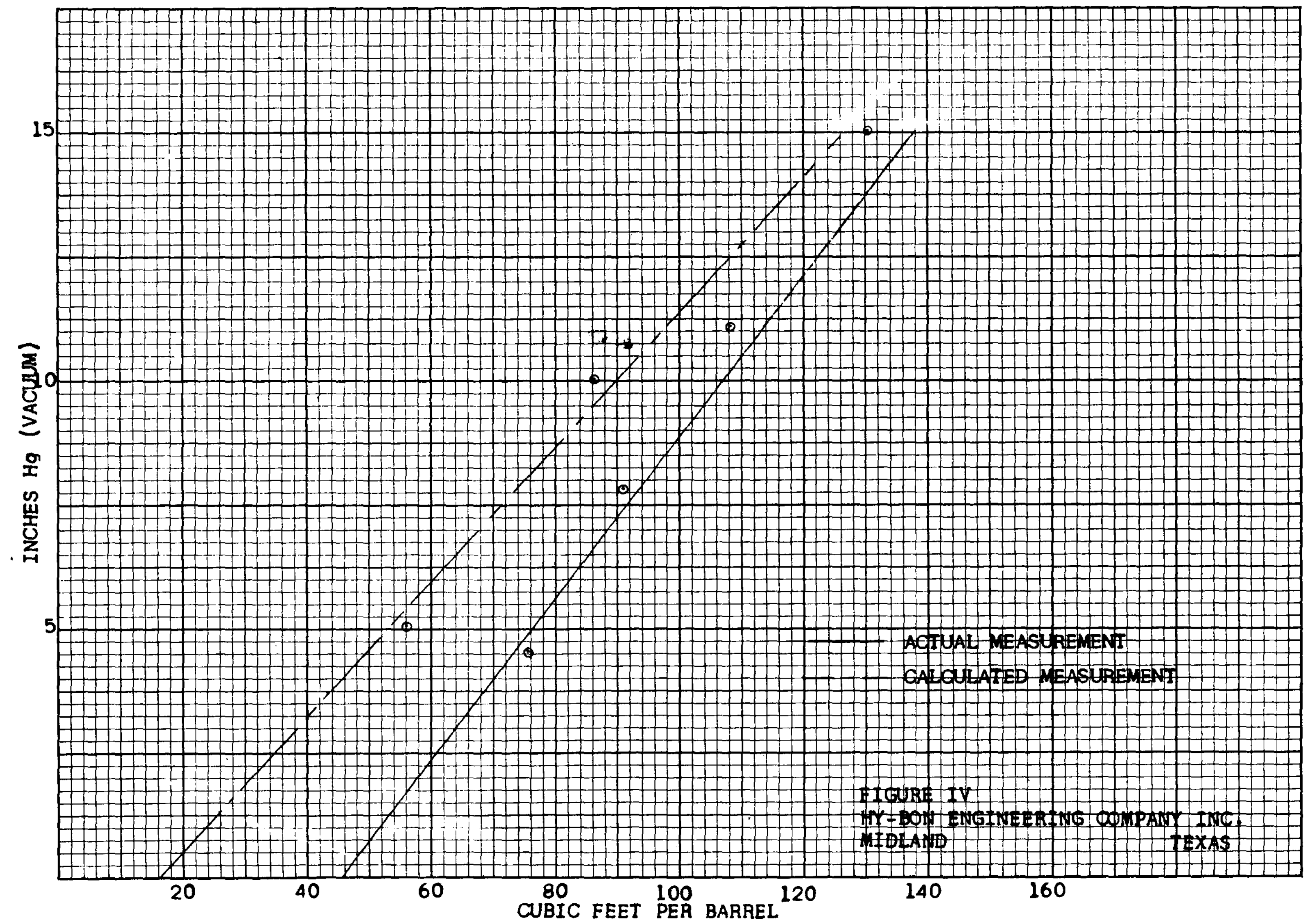


FIGURE IV
HY-BON ENGINEERING COMPANY INC.
MIDLAND TEXAS

since the normal installation will utilize the casing vented to flow line at the well head, an increase of pressure at this point will have a definite effect upon production and pumping fluid level. In order to evaluate this application one of several methods can be used to determine the economics; basically the economics are determined by obtaining the production rate increase with the reduction of casing pressure, the volume of gas to be displaced for a specific casing pressure, refer to Figure 2 to estimate the installation cost. The most economical system to reduce the individual pumping well casing pressure is with a central compressor unit controlling the separator or treating system pressure at the tank battery; this will require the unit to maintain a constant suction pressure and discharge all lease gas into the gas gathering line. The reduction of pressure at the tank battery has been found to be a ratio of at least 1:2 reduction at the casing; this is generally due to 3 phase flow conditions in the flow line. Installations have been made whereby the casing is connected to a gathering line and pressure maintenance effected on an individual well control basis. The cost of the gathering system and controls can effect the economics of leases with small production increases.

The application of reducing casing pressure of pumping wells can be utilized into other applications on the same lease to further enhance the economics. The aforementioned method of reducing tank battery treating or separator pressure at the tank battery will also recover a percentage of vapors normally lost in the battery stock tank. The centralized gas compressor unit can also be designed for operating suction pressure conditions whereby stabilization of produced crude oil gravity is effected. Crude oil which has been stabilized to pipeline requirements can be marketed; this can alleviate storage facilities and essentially permit sale of the crude oil direct from the treating system through an automatic custody transfer unit. In lieu of this application concerning marginal pumping wells, the daily production rate increase can justify installation of equipment to cover the basic operation or additional for complete automation.

Treating System Vapor Recovery

Centralized Tank Batteries and normal treating systems have become prominent to most areas of oil production; accompanying this centralization has also indicated problems of pressure balance in the producing system. Erratic flow rates, high gas gathering line pressure, and the effects upon upstream production rates has justified installation of compressor(s) for booster service to the gas sales line. The treating pressure can be maintained to a point of lowest requirement and effectively displace the gas into a gas sales line with fluctuating pressures; this application can be easily justified whenever flaring of the treating system gas is frequent. The volume of gas can vary because of long flow lines unloading, intermittent type lifting devices; thus to handle this problem a multiple compressor unit can be used to cycle at overlapping pressure settings. In the event of a complex treating system, utilizing free water knockout, salt water disposal tank, and treating system, a closed system can be installed and economically justified to gather and compress all vapors into the sales line. The control system for this application can be designed for many functional conditions; the standard stock tank vapor recovery system can be modified for this application which results in a lower installation cost.

High Gravity Crude Oil Stabilization

The centralized tank battery with relatively high flow rates and crude oil gravity becomes an application for crude oil gravity reduction and stabilization. The economics of this application are very startling, especially whenever the operator has a large percentage of the gasoline plant ownership. Modification of the standard stock tank vapor recovery compressor unit can be made with additional control system and stabilizing tower to suffice for this application. Fig. IV illustrates the vapor volume (cu ft per bbl) versus inches Hg vacuum, sustained during one pass of fluid. The theoretical curve was based upon 60° F, 14.65 psia, 47° API gravity crude oil sample; the actual curve was based upon 47° API gravity crude, 115° F inlet, gpm was 29.43, volume shrinkage at 15 in. Hg was 10 percent. An installation of this application would be justified for crude oil gravity stabilization and control; thus since this is effected, sale of the crude oil can be made as produced.

CONCLUSION

The preceding data is presented to illustrate the many applications that exist at normal tank batteries. Equipment design and installation costs have broadened the range of application from stripper well leases to top allowable leases; thus the application is available, justification becomes the problem. Economics of a vapor recovery installation can be derived from the sale of recoverable gas and liquid products; lease safety by collection and disposal of lethal gas; reduction in tank deck corrosion; crude oil gravity stabilization; sale of liquids as condensate allowable; control of lease gas hazard on townsite locations; control of crude oil gravity for pipeline sale; crude oil production increase through well casing pressure control. The system is fully automatic and designed for unattended operation, field proven by several years service and sufficient data available from experience to determine the most economical system. Needless to say, we have answered the question of "Why Vapor Recovery?"