

1992

# Separation of Suction Gas from the Discharge Gas and Benefits of Feeding the Gas Directly to the Crankcase

P. K. Roy  
*Bristol Compressors*

M. A. Di Flora  
*Bristol Compressors*

Follow this and additional works at: <https://docs.lib.purdue.edu/icec>

---

Roy, P. K. and Flora, M. A. Di, "Separation of Suction Gas from the Discharge Gas and Benefits of Feeding the Gas Directly to the Crankcase" (1992). *International Compressor Engineering Conference*. Paper 934.  
<https://docs.lib.purdue.edu/icec/934>

This document has been made available through Purdue e-Pubs, a service of the Purdue University Libraries. Please contact [epubs@purdue.edu](mailto:epubs@purdue.edu) for additional information.

Complete proceedings may be acquired in print and on CD-ROM directly from the Ray W. Herrick Laboratories at <https://engineering.purdue.edu/Herrick/Events/orderlit.html>

# Separation of Suction Gas from the Discharge Gas and Benefits of Feeding the Gas Directly to the Crankcase

Prasanta K. Roy and Michael A. Di Flora  
Bristol Compressors, Bristol, VA (U.S.A)

## ABSTRACT

Despite its advantageous characteristics, the separation of suction gas from the discharge gas and utilization of polymer suction and discharge valves has only recently been attempted due to the difficulties in manufacturing and the lack of availability of suitable polymers. However, in recent years, production technique and polymer materials have been greatly improved.

Advances in design and manufacturing engineering have led to the introduction of the Inertia compressor. Using gas separation and polymer valves it is possible to achieve high efficiency and reliability under a wide range of compression ratios. For this reason, the Inertia compressor is very suitable and highly efficient for the application of heat pump air conditioners.

## INTRODUCTION

After the Energy Crisis, energy conservation has been the most important topic in the field of air conditioning. In the United States, the regulation of system efficiency started in 1992. Besides the legal demand, air conditioners with higher efficiency have been required from the distributors to meet the customer's needs concerning energy savings.

In such a situation, there came a strong demand for higher efficiency compressors, because the improvement of compressor efficiency is the most economical method to increase unit efficiency in spite of technological difficulties. Thus, most compressor manufacturers have been eagerly improving conventional compressors and developing new ones.

The Inertia compressor is a new generation of reciprocating compressor, separating suction gas from the discharge gas and utilizing polymer suction and discharge valves.

In the standard reciprocating refrigeration compressor the normal route of the suction gas flow is through a cylinder head that is divided into two chambers, suction and discharge. The suction gas picks up heat from the discharge chamber, raising its temperature prior to entering the cylinder. Also, the pressure decreases as it passes through the suction chamber (the small suction port area in the valve plate) and the restricted opening of the suction valve.

In the Inertia compressor the cylinder head is exclusively utilized for high side pressure and temperature. This arrangement reaps the benefits which will be discussed below.

Because the suction gas flows directly into the piston suction ports, which are separated from the hot discharge gas in the cylinder head, the valve plate and discharge valve assembly contain hot exiting gas only.

## DESIGN FEATURE

The suction gas enters through the suction tube, flows into the housing and through an opening in the motor cap. From the motor cap, the inlet gas is routed through the left and right side suction tubes, through the plastic manifolds, into the crankcase side ports, and into the piston suction port areas. (Fig. 1) Because the suction gas is separated from the discharge gas, it does not conduct any heat from the discharge chamber, therefore, its temperature is much lower as shown in the temperature profile (Fig. 2).

This gas separation design incorporates suction ports in the piston body and a polymer suction valve on the sculptured top of the piston. The suction gas flows smoothly into the piston ports and through the 360° opening of the suction valve (Fig. 3).

Another special feature of the design incorporates the use of a polymer discharge valve with a deeper head in the steel valve plate assembly (Fig. 4). This reduces the cylinder clearance volume by ~ 50%. The larger volume head facilitates smoother flow and exit of the high temperature and pressure discharge gas.

## CALCULATION

Volumetric Efficiency  $\eta_v$ :

$$\eta_v = \frac{m_a}{m_t} = \frac{\text{Actual mass of new gas entering the compressor per stroke}}{\text{Theoretical mass of gas represented by the displacement volume and determined at the pressure and temperature at the compressor inlet}}$$

$$= \frac{\text{Actual lbs/hr}}{\text{Theoretical lbs/hr}} = \frac{\text{Actual volume rate}}{\text{Theoretical volume rate}}$$

$$= \frac{\text{CFM (ft}^3/\text{min)} \times 1728 \text{ (in}^3/\text{ft}^3)}{\text{in}^3/\text{rev} \times \text{rev/hr}}$$

Check Units:

$$= \frac{\text{BTU/Hr} \times v \text{ suction (ft}^3/\text{lb)} \times 1728 \text{ (in}^3/\text{ft}^3)}{\text{in}^3/\text{rev} \times \text{RPM (rev/min)} \times \Delta h \text{ (BTU/lb)} \times 60 \text{ (min/hr)}}$$

where  $v$  suction = specific volume at compressor inlet,  $\text{ft}^3/\text{lb}$  ( $=1/\text{density}$ )

$\Delta h$  = [Enthalpy (superheated) at compressor inlet temperature -  
Enthalpy (saturated liquid) at expansion valve], BTU/lb.

From refrigerant -22 chart, at 45°F evaporator, and 130°F condenser:

15° subcooling (130-15) results in 115°F at expansion valve

h @ 115°F saturation liquid at expansion valve = 44.065 BTU/lb

v @ 65°F = 0.64106 cu. ft/lb

h @ 65°F = 112.128 BTU/lb

$\Delta h$  @ 65°F = 112.128 - 44.065 = 68.063 BTU/lb

$$\eta_v = \frac{\text{BTU/Hr} \times \text{suction (ft}^3/\text{lb)} \times 1728 \text{ (in}^3/\text{ft}^3)}{\text{in}^3/\text{rev} \times \text{RPM (rev/min)} \times \Delta h \text{ (BTU/lb)} \times 60 \text{ (min/hr)}} \quad \text{Equation 1}$$

$$= \frac{\text{BTU/Hr} \times v \text{ suction} \times 28.8}{\text{in}^3/\text{rev} \times \text{RPM} \times \Delta h} \quad \text{Equation 2}$$

$$\text{Therefore, } \eta_v \text{ (ARI) @ 65°F return gas (ARI rating point)} = \frac{\text{BTU/Hr} \times .64106 \times 28.8}{\text{in}^3/\text{rev} \times 3500 \times 68.063} = \frac{\text{BTU/Hr}}{12902.9 \text{ in}^3/\text{rev}} \quad \text{Equation 3}$$

$$\text{Mass flow rate} = m \text{ (lbs/hr)} = \frac{\text{BTU/Hr}}{\Delta h \text{ (BTU/lb)}} \quad \text{Equation 4}$$

$$\text{Therefore, } m \text{ @ 65°F return gas (ARI rating point)} = \frac{\text{BTU/Hr}}{68.063}$$

From equation 3,  $\eta_v \propto \frac{1}{\text{in}^3/\text{rev}}$ , BTU/Hr = constant between standard and inertia pumps.

Therefore,  $\eta_v$  is higher if the displacement is lower or BTU/in<sup>3</sup> is higher, which is the case of Inertia pumps.

## CONCLUSION

In the Inertia compressors, the separation of suction gas from the discharge gas with the utilization of polymer suction and discharge valves results in the following benefits:

- a. Lower suction temperature (Fig. 2)
- b. Reduced clearance volume (Fig. 5)
- c. Higher volumetric efficiency,  $\eta_v$  (Fig. 6)
- d. Higher BTU/cu. in. (Fig. 7)
- e. Higher EER. (Fig. 8)

## ACKNOWLEDGEMENT

The authors would like to acknowledge the substantial contribution to this paper by David Gilliam and Hugh Stringer. The authors also wish to thank Bristol Compressor's upper management for their support and permission to publish this paper.

## REFERENCES

- [1] ASRAE Handbook, Fundamentals, 1.9
- [2] Thermodynamics - J.P. Holman

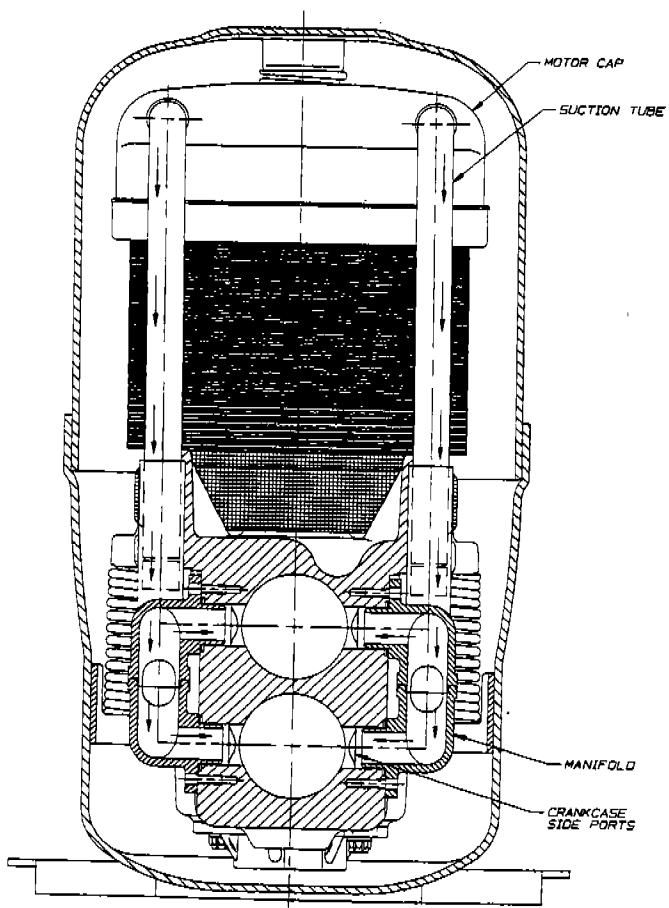


FIG. 1



# Temperature Profile at ASRE/T (ARI in Parenthesis)

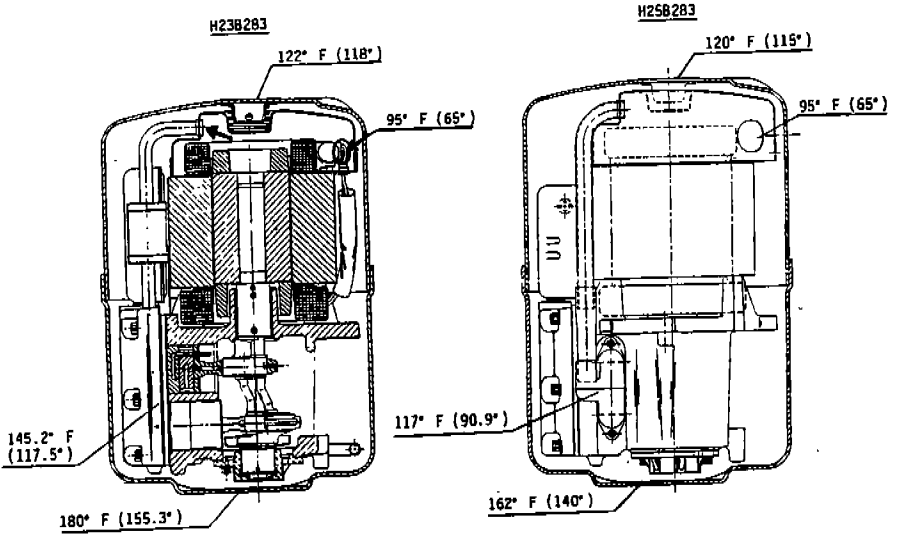


FIG. 2

**Bristol Compressors'**

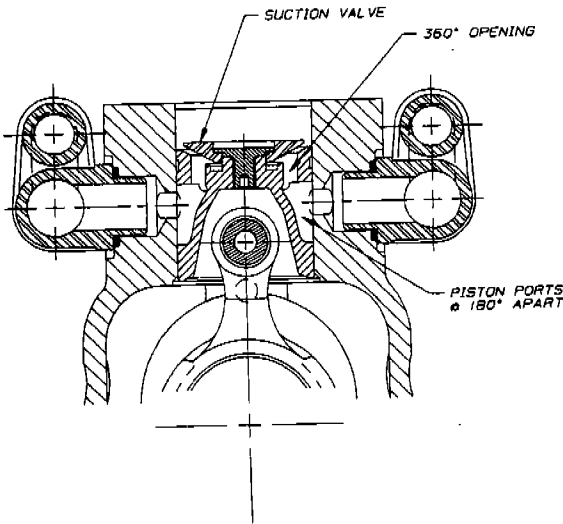


FIG. 3

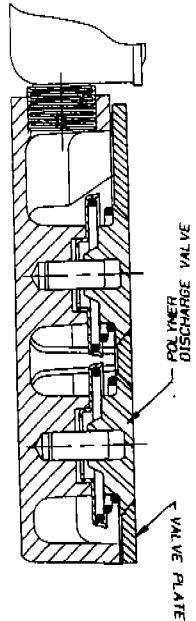


FIG. 4

Clearance Volume (%) vs. Displacement (in<sup>3</sup>)  
Inertia vs. Standard Reciprocating

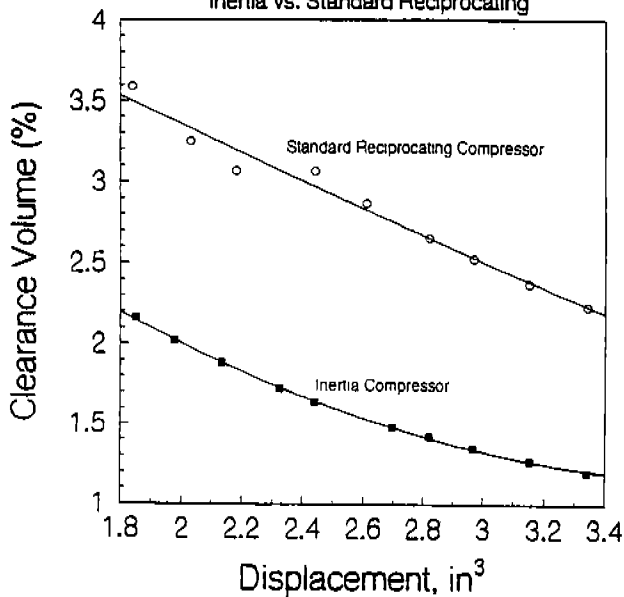


FIG. 5

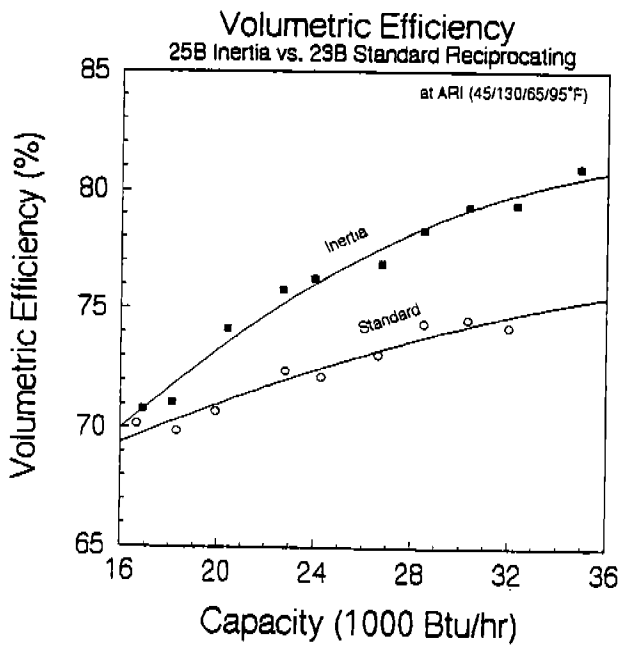


FIG. 6



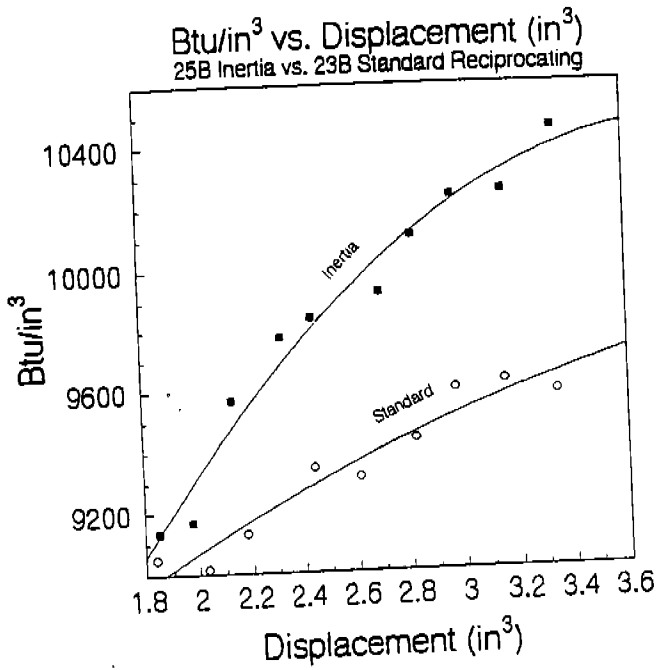


FIG. 7

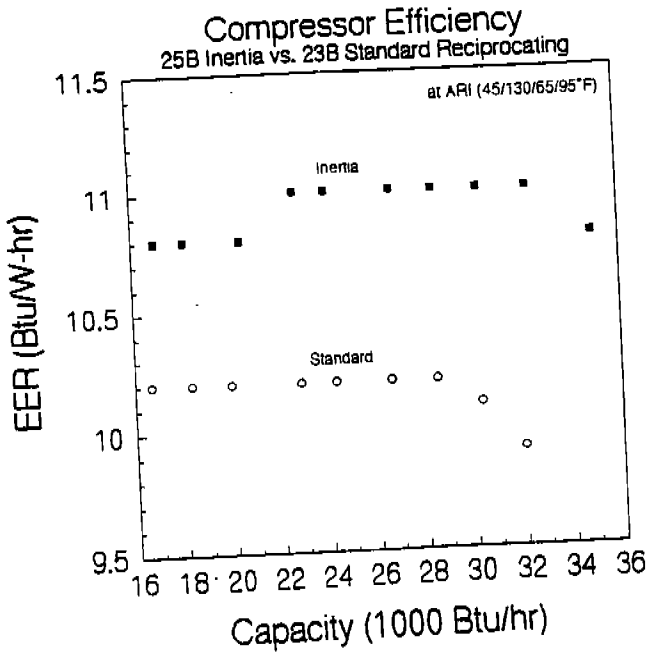


FIG. 8