Development of UHTREX Gas-Bearing Compressors*

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Two helium blowers operating on hydrodynamic gas-bearings have been developed by Mechanical Technology Incorporated for the Los Alamos Scientific Laboratory. These blower designs were selected for use in the Ultra High Temperature Reactor Experiment (UHTREX) because of the highly radioactive system contamination resulting from the investigation of unclad fuel elements.

The smaller of the two blowers is designed for the gas cleanup loop through which about one percent of the primary loop coolant will be diverted for the removal of fission products and other impurities. With helium at 495 psi and 100°F, the blower is designed to produce a pressure rise of 15 psi at a flow of 120 lb/hr. Figure 1 is an isometric drawing of the blower showing some of the major components. The electric motor armature, the regenerative impeller, and the bearing journals are on a common shaft. The 3-phase, 2-pole, squirrel-cage induction motor drives the $5\frac{1}{4}$-inch diameter, 36-vane regenerative impeller at 12,000 rpm. The rotor assembly is balanced to about 60 microinches of shaft displacement

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at the design speed. Hydrostatic journal bearings, requiring an external source of 12 psi additional pressure, are used to raise the rotor assembly to avoid wear during stopping and starting intervals when the hydrodynamic bearings are not operating within their design range. Each of the hydrodynamic journal bearings consist of four, 80° arc, tilting-pads which become self-acting at 3600 rpm and have been proven stable up to 14,000 rpm. The thrust bearing has two stationary Whipple groove thrust plates pumping radially inward. A centrifugal fan circulating helium through a water heat exchanger at approximately 200 lb/hr cools the shaft journals and motor. The pressure containment vessel was designed to 550 psi at 200°F in accordance with the ASME pressure vessel code and its applicable nuclear cases. Shaft position can be monitored with capacitance type distance probes to an accuracy of 100 microinches. Design conditions were met at 12,250 rpm with a motor operating at 3.8 horsepower as shown in the performance curve of Fig. 2.

The over-all performance curve in Fig. 3, which is a plot of nondimensional flow coefficient versus head coefficient, indicates that this machine is capable of producing a pressure rise of 30 psi at design flow and temperature. Figure 4 shows the approximate efficiency of the compressor with respect to the flow coefficient. Note that the over-all efficiency is about 10% at the design conditions.

The large blower is designed for either of the two main helium coolant loops. With helium at 510 psi and 600°F, the blower is designed to produce a pressure rise of 8 psi with a flow of 10,250 lb/hr. Figure 5 is an isometric drawing of the blower showing some of the major components. The electric motor rotor, the centrifugal impeller, and the shaft journals for both hydrostatic and hydrodynamic operation are combined on one 50-pound rotor assembly. The 3-phase, 2-pole, squirrel-cage induction motor rated at 65 horsepower at 12,000 rpm drives the opened face, $11\frac{5}{8}$-inch diameter, 19-vane centrifugal impeller. Hydrostatic journal bearings, with 25 to 30 psi extra pressure, raise the rotor assembly during starting and stopping while the hydrodynamic bearings are not self-acting. Thrust bearings are of tilting-pad design using the back of the cooling fan as the thrust runner. A fan circulating helium at approximately 1000 lb/hr cools shaft-journals, motor, and pressure containment vessel. Other design concepts are the same as for the gas cleanup loop blower. Primary loop conditions were met at 11,000 rpm with the motor operating at 49 horsepower as shown in the performance curve of Fig. 6. Both the actual performance curve and the over-all performance curve of Fig. 7 indicate that this machine is capable of producing a pressure rise of 9.8 psi at design flow and temperature with the available horsepower. Figure 8 shows the approximate efficiency of the compressor with respect to flow coefficient.

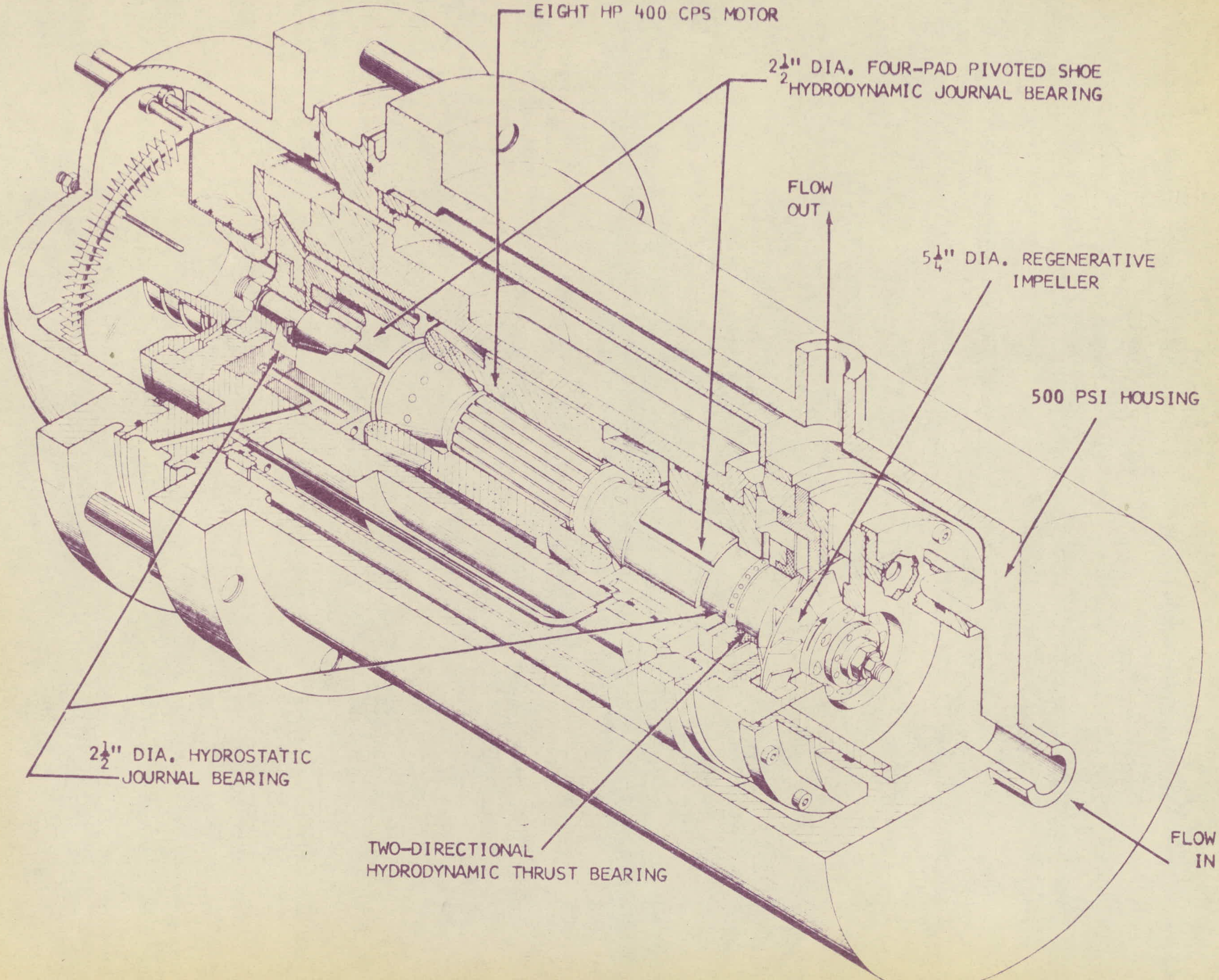


Fig. 1 - UHTREX Gas Cleanup System Regenerative Blower

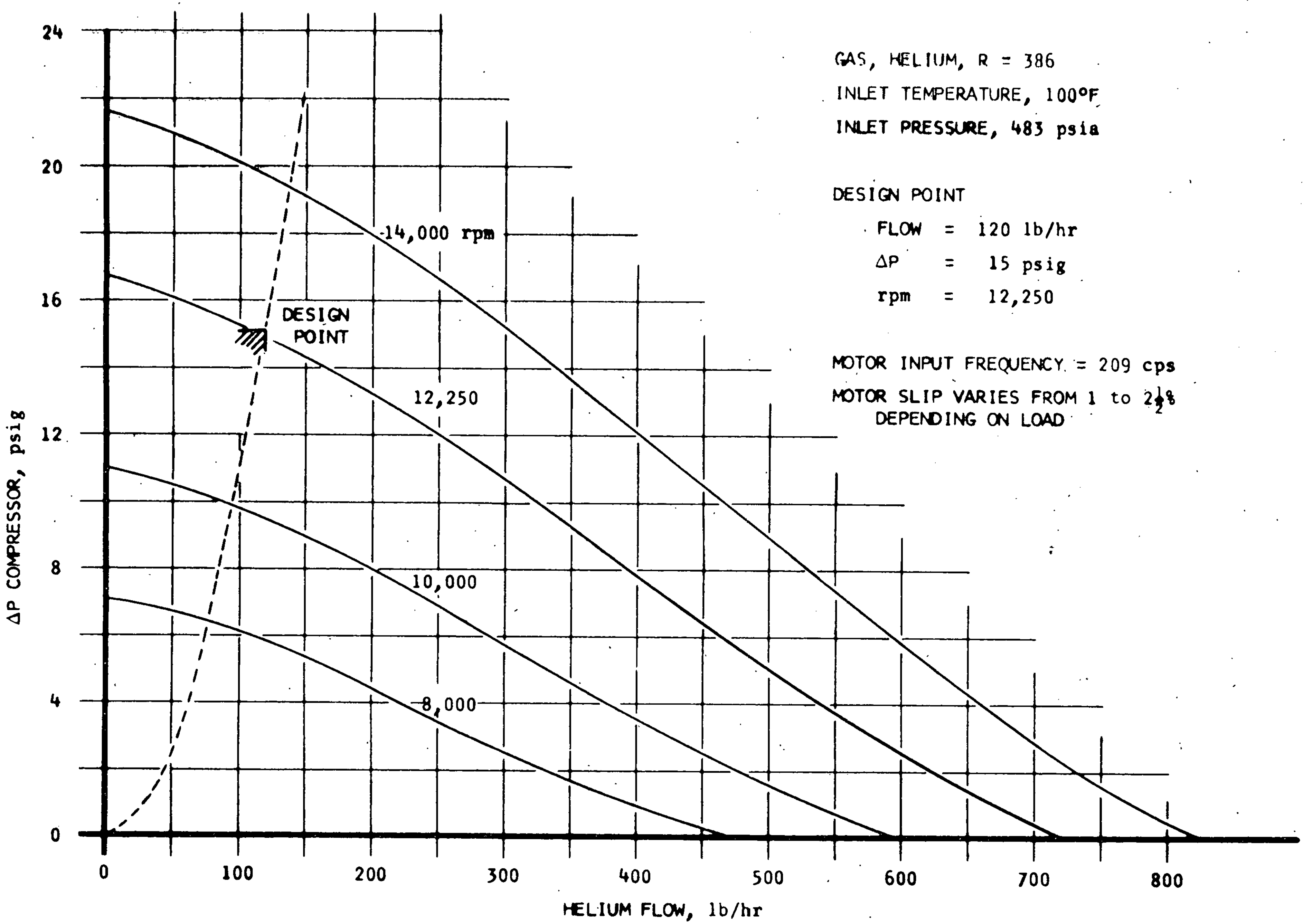


Fig. 2 - Pressure Rise vs Flow Curve for UHTREX Gas Cleanup System Regenerative Blower

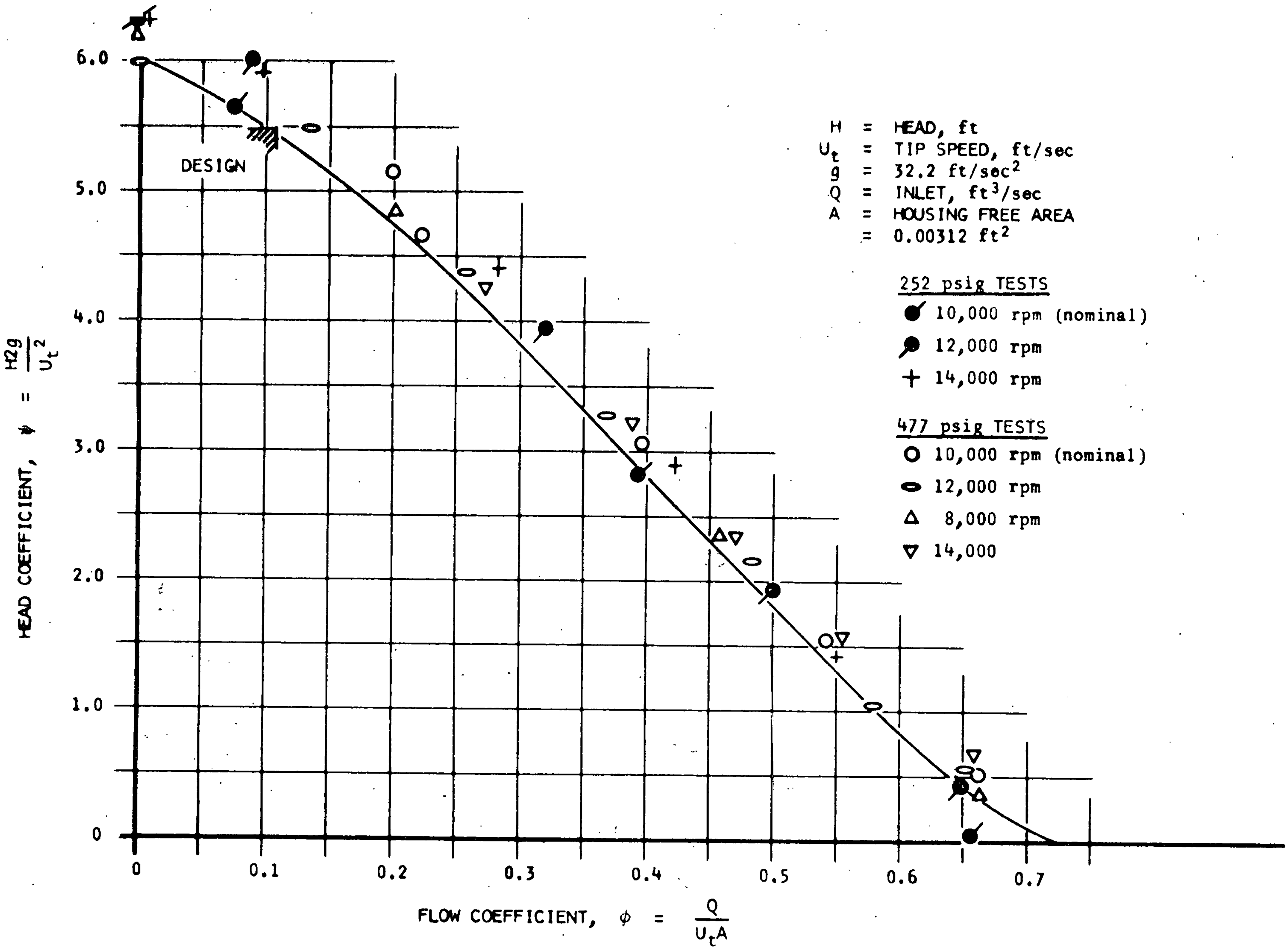
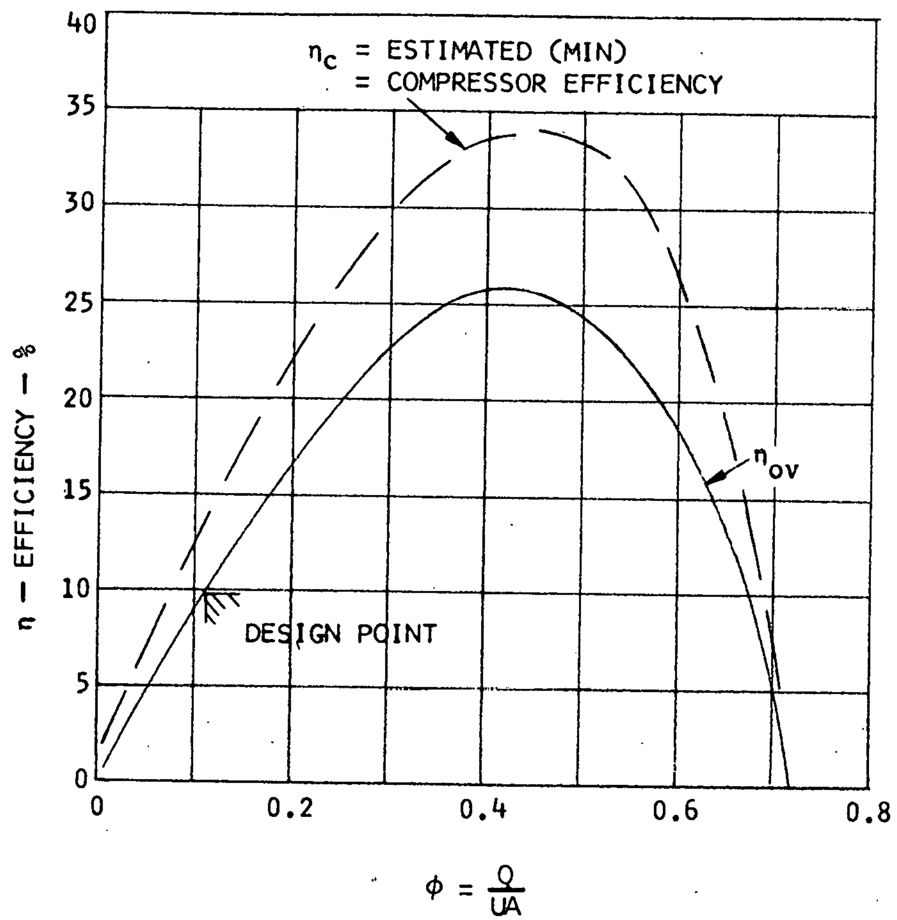


Fig. 3 - Over-all Performance Curve for UHTREX Gas Cleanup System Regenerative Blower



η_{ov} = OVER-ALL EFFICIENCY

$= \frac{\text{ADIABATIC GAS HP}}{\text{INPUT HP TO MOTOR}}$

INCLUDES:

1. COOLING FAN POWER
2. BRG AND ROTOR WINDAGE POWER
3. MOTOR EFFICIENCY

Fig. 4 - Over-all Efficiency Curve for UHTREX Gas Cleanup System Regenerative Blower

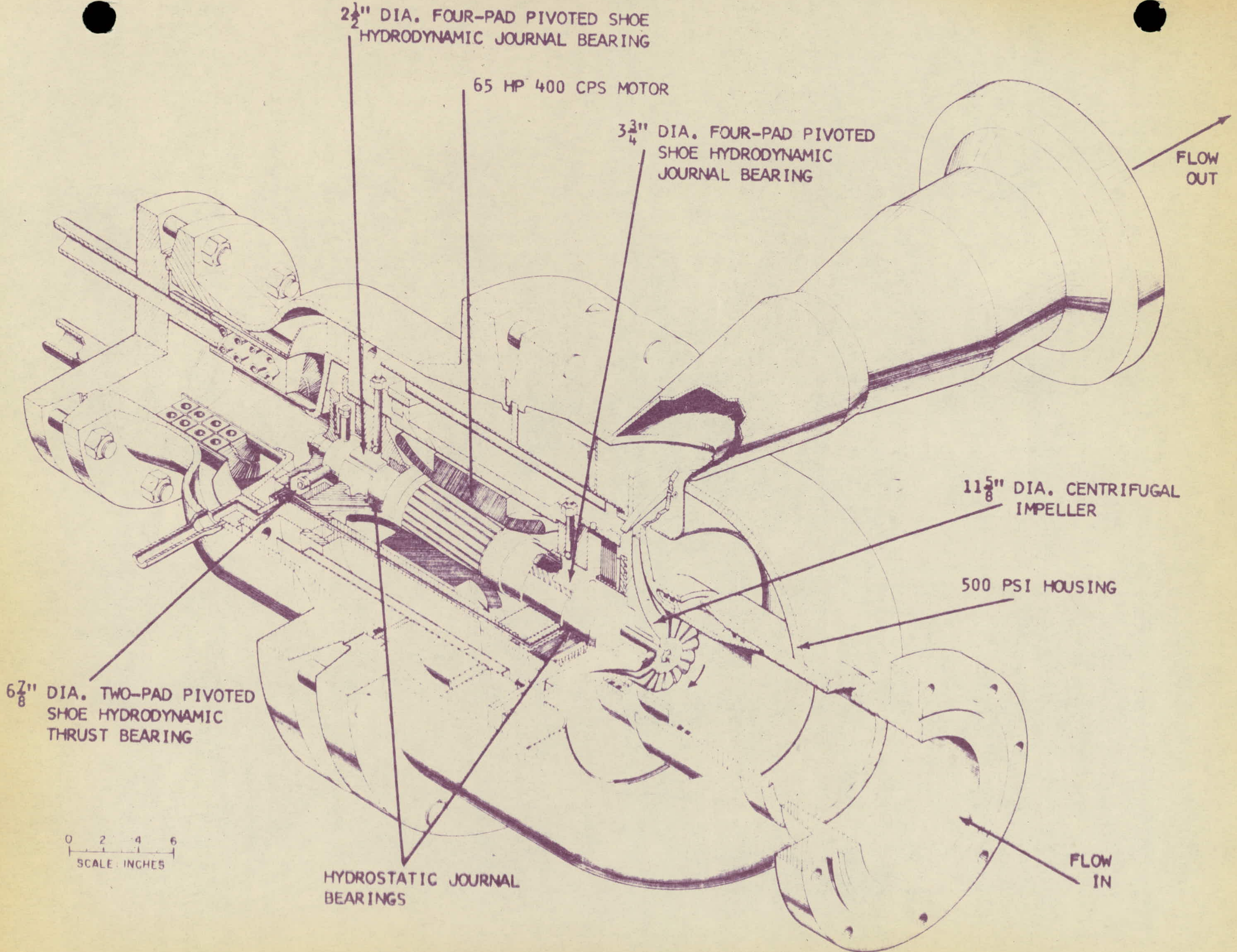


Fig. 5 - UHTREX Main Helium Blower

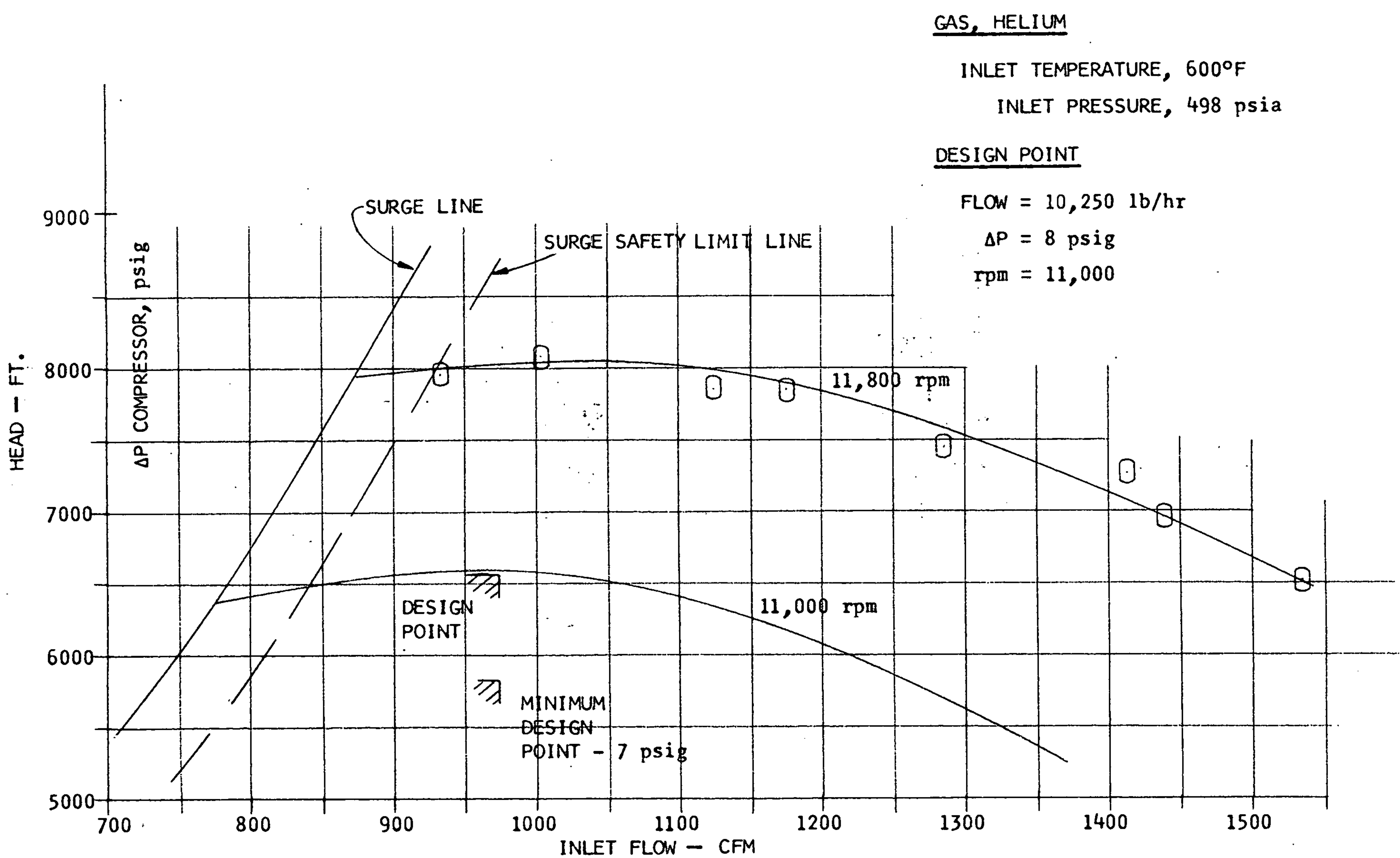


Fig. 6 - Head vs Flow Curve for UHTREX Main Helium Blower

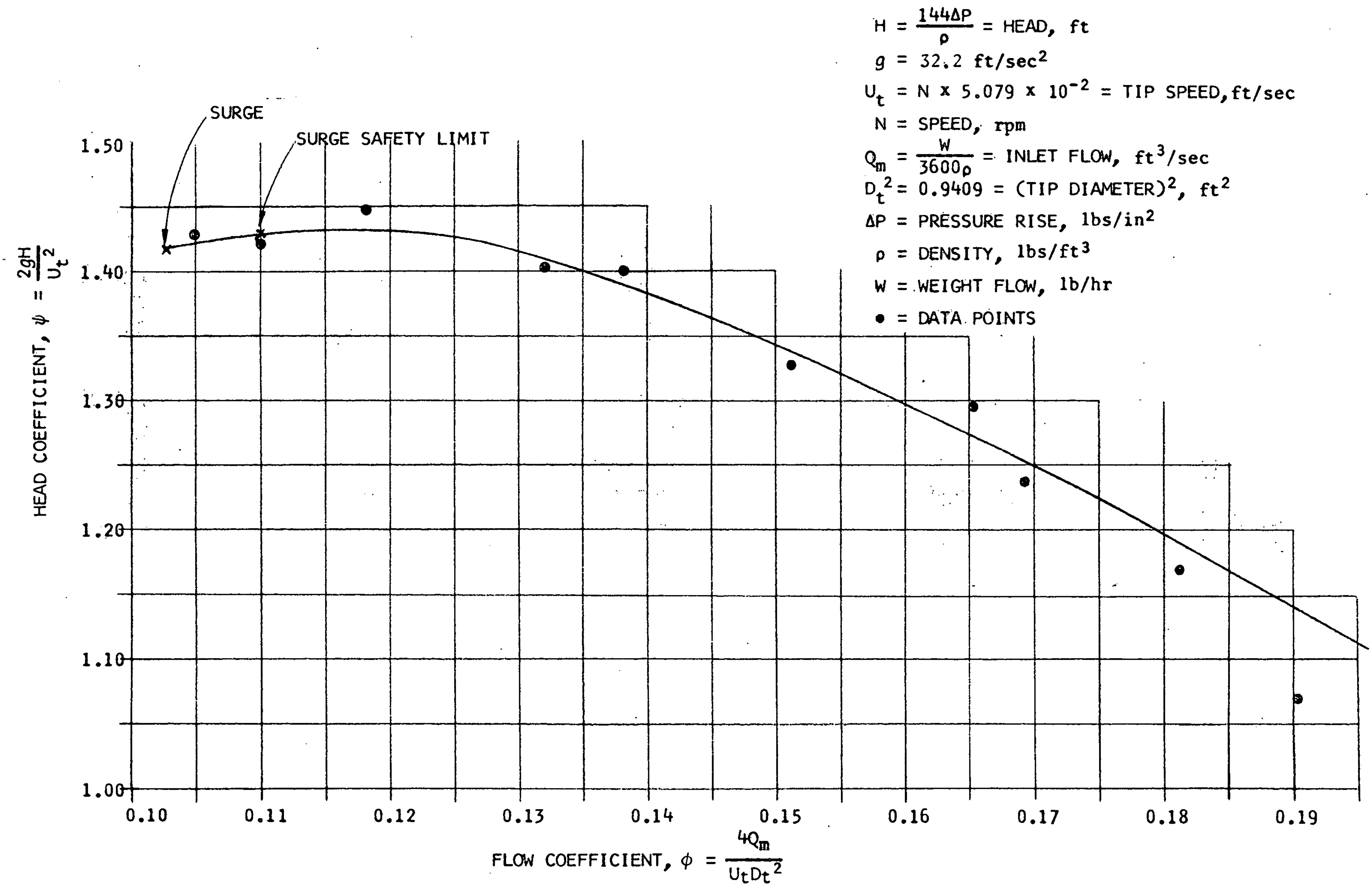
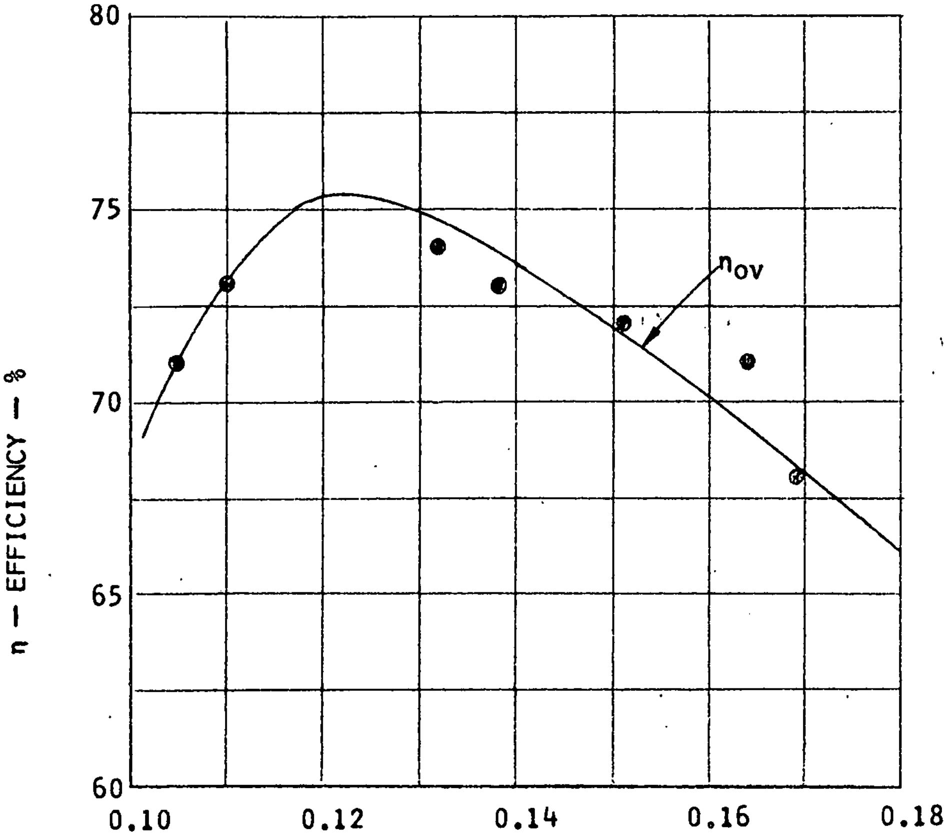


Fig. 7 - Over-all Performance Curve for UHTREX Main Helium Blower



$$\phi = \frac{4Q_m}{U_t D_t^2}$$

• = TEST DATA POINT

η_{ov} = OVER-ALL EFFICIENCY

$$= \frac{\text{ADIABATIC GAS HP}}{\text{INPUT HP TO MOTOR}}$$

INCLUDES:

1. COOLING FAN POWER
2. BRG AND ROTOR WINDAGE POWER
3. MOTOR EFFICIENCY

Fig. 8 - Over-all Efficiency Curve for UHTREX Main Helium Blower