600.0 Computation of Results

601.0 *Results Required*

The usual results desired are the computed coordinates based on the test data, which provide a comparison with the characteristic curves, issued by the pump manufacturer. (See Figure 702.2.1 characteristic curve.)

601.1 The coordinates needed for a point on the characteristic curves are total head and capacity, power and capacity, available net positive suction head and capacity, or efficiency and capacity.

602.0 *Total Head*

Total Head is the hydraulic energy added to the pumped fluid, i.e., the algebraic difference between the total discharge head and total suction head.

602.1 Readings of pressure gauges in customary (U.S.) units are converted to pounds per square inch absolute and then to feet of liquid head to obtain static head. Readings of SI Units are converted to kPa and then to meters of head of liquid. (See example in Section 803.0) Static head is defined in Section 200.0. Due regard must be paid to correcting for gauge location with regard to the chosen datum line.

602.2 The velocity used for determining the velocity head (suction or discharge), as defined in Section 200.0, may be obtained from the volume rate of flow and the cross-sectional area at the measurement section. Velocity is determined by:

$$v = \frac{Q}{448.8\,A} \text{ for customary units}$$

$$v = \frac{Q}{A} \text{ for SI units}$$

Note: 1 ft^3/ sec = 448.8 gpm

602.3 Flow to be used for determining liquid velocity may also be calculated from the following orifice flow equation:

$$Q = 448.8\, C\, A \sqrt{2gh} \quad \text{for customary units}$$
$$Q = C\, A \sqrt{2gh} \quad \text{for SI units}$$

C = meter coefficient (see reference 805.2 for typical coefficients)
h = differential head of fluid pumped as computed from the manometer head across the orifice
g = acceleration of gravity, 32.2 ft/ sec^2 or 9.81 m/sec^2 for SI units

603.0 *Capacity*

Capacity or volume rate of flow is in terms of cubic feet per second for calculation purposes and as gallons per minute for reporting purposes. The following equations may be used as they apply:

$$Q,\ \text{ft}^3/\text{sec} = \frac{\textit{weight rate of flow},\ \frac{lb}{\text{sec}}}{\textit{specific weight},\ \frac{lb}{ft^3}}$$

$$Q,\ \text{ft}^3/\text{sec} = \frac{\textit{volume rate of flow, gpm}}{(60\,\text{sec/min})\ \ (7.48\ gal/ft^3)}$$

$$Q,\ \text{ft}^3/\text{sec} = (\text{velocity, ft/sec})\ (\text{area, ft}^2)$$

604.0 *Power*

The characteristic power curve is an indication of the rate of doing work applied to the pump.

604.1 Operating Driver Brake Horsepower or

$$H_p = \frac{(\textit{watts input})\ \ (\textit{motor efficiency})}{746}$$

Where a wattmeter is not used to obtain the input, the following is used on 3-phase motors:

watts input = (1.73) (phase voltage) (average phase amperage) (power factor)

604.2 Where other machines provide the power input, the manufacturer can supply means of obtaining this power. For example, a steam turbine driver might use nozzle block steam pressure, exhaust steam pressure and efficiency to determine the brake horsepower.

605.0 *Efficiency*

The pump power output combined with the efficiency (P_w/H_p) at any point may provide a check on the driver brake horsepower, or combined with the driver brake horsepower, used to determine efficiency.

605.1 Pump hydraulic power output is found by the following formula:

$$P_w = \frac{\text{(lb liquid pumped/min)(total developed head)*}}{33{,}000} \text{ for customary units}$$

$$P_w = \frac{\text{(kg liquid pumped/sec)(total developed head)*}}{101.9} \text{ for SI units}$$

* Not discharge pressure

If the liquid is of specific gravity (s) with reference to water at 69° F,

$$P_w = \frac{s\,Q\,H}{3{,}960} \text{ for customary units}$$

$$P_w = 9.81 \; s\,Q\,H \text{ for SI units}$$

605.2 Pump efficiency is then determined as follows:

$$eff = \frac{output}{input} = \frac{P_w}{H_p}$$

606.0 *Speed*

Where the test speed, n_t is different than the speed used to develop the characteristic curves, the values of the coordinates may be estimated by the following equations:

$$Q = Q_t \left(\frac{n}{n_t} \right)$$

$$H = H_t \left(\frac{n}{n_t} \right)^2$$

$$\text{NPSH approximates* } NPSH_t \left(\frac{n}{n_t} \right)^2$$

$$P_w = P_{w\,t} \left(\frac{n}{n_t} \right)^3$$

where H = pump total head
n = speed of rotation

* for a specific pump design the exponent of the speed ratio may vary from 1.7 to 2.0 and can only be determined by testing.

Where the subscript "t" refers to the conditions at the test speed. Variations between the test speed and the characteristic curve speed that exceed 10% could affect the validity of the comparison.

607.0 *Impeller Diameter Variation*

Where the impeller diameter is different than the diameter used by the manufacturer to develop the characteristic curves, the values of the coordinates may be estimated by the following equations:

$$Q = Q_t \left(\frac{D}{D_t} \right)$$

$$H = H_t \left(\frac{D}{D_t} \right)^2$$

$$P_w = P_{w\,t} \left(\frac{D}{D_t} \right)^3$$

608.0 *Sample Test-Run Data Sheet*

Pump Type________________	Pump Serial No.______________
Pump Size________________	Rated Capacity______________
Pump Manufacturer__________	Rated Head________________
Pump No. of Stages__________	Impeller Diameter____________
Driver Type________________	Rated Horsepower____________
Driver Speed________________rpm	Driver Serial No. ____________
Suction Temperature__________°F	Suction Pressure♠____________
Liquid Type________________	NPSHR____________________
Specific Gravity______________	Viscosity Absolute____________
Barometric Pressure__________mm.Hg	Pressure (liquid surface) suction ____
Discharge Pressure♠__________psig	Pressure (liquid surface) discharge___
Motor Input Amps____________amps	Motor Input Volts____________
Motor Power Factor___________	Motor Power Input____________
Turbine Nozzle Ring Pressure_____psig	No. of Nozzles ____________
Turbine Back Pressure__________psig	

♠ Corrected for elevation above or below datum elevation

System Sketch: (User to include the sketch for the actual application here)