400.0 Instrumentation and Measurement Methods

401.0 *Introduction*

This section presents detailed information on instruments and methods of measurement most commonly used in the field testing of centrifugal pumps.

401.1 For pump testing, it is necessary to determine:

401.1.1 Pressure (suction, discharge, barometric), corrected for difference in elevation of pressure gauge and selected datum plane.

401.1.2 Temperature (liquid, and local ambient air),

401.1.3 Rate of flow,

401.1.4 Pump speed,

401.1.5 Driver power input.

401.2 For the liquid being pumped:

401.2.1 Specific gravity,

401.2.2 Viscosity,

401.2.3 Vapor pressure.

402.0 *Accuracy and Precision*

Field test results are dependent on the accuracy of the measurements and assumptions. Care must be given in measuring those items that would affect the accuracy of the testing variables before challenging actual test stand results.

402.1 *Accuracy*

Instruments or measuring devices should be calibrated over the expected operating range against known standards. The accuracy of all data should be determined, and the effects on the test results considered.

402.2 *Precision*
Instruments should be selected that will measure the variable at the point of highest precision, if at all possible. This is frequently the mid-range of the selected instrument. The precision of an instrument is usually reflected by its smallest scale graduations. Instrument readings recorded should reflect this precision.

403.0 *Measurement of Test Parameters*

403.1 *Instruments and Indicating Devices* suitable for this test are given in the following.

403.2 *Pressure Measurements*

403.2.1 The measurement of pressure for the determination of head is carried out by pressure indicating devices (columns, manometers, gauges or transducers) connected with the liquid passage through pressure taps. In some cases, the measurement is obtained through pressure transmitters which are in turn connected to the liquid passage through pressure taps. When transmitters are used, the transmitter and the pressure-indicating device are considered as one complete instrument and are to be calibrated as a unit.

403.2.2 All gauge line connections must be tight. All instrument hose, piping, fittings, valves, etc. should be checked under pressure prior to the test to assure that there are no leaks. Connecting lines should be vented to remove all gas.

403.2.3 The suction head could be approximated by measuring the distance the level of the suction liquid is above or below the centerline of the pump suction minus the calculated losses in the suction piping plus the suction surface pressure.

403.2.4 Pressure Taps

403.2.4.1 Pressure taps in the pipe should be flush with and normal to the wall of a cylindrical portion of the liquid passage. The interior edge of the pressure tap hole should be free of burrs and roughness, as these will cause turbulence, which may interfere with obtaining a true pressure reading. Pressure taps in or within five pipe diameters downstream of an elbow should be avoided.

403.2.4.2 Pressure readings may vary at different points on the periphery of a pipe, owing to disturbances in the flow pattern caused by internal roughness, a close proximity to fittings, a misplaced gasket, etc. Therefore, the pressure should preferably be determined at a location where flow disturbances are expected to be minimal.

403.2.4.3 Many materials can cause difficulties or inaccurate readings by corroding, plugging and freezing or condensing in these pressure connections at atmospheric temperatures or operating pressures. To prevent errors it may be necessary to use a buffer fluid between the measuring device and the operating fluid. If the specific gravity of the buffer fluid is different than the that of the fluid being pumped, the measurements will have to be adjusted to reflect this difference. Measuring devices may also be isolated by diaphragms.

403.3 *Temperature Measurement*

If temperature variations during the test have substantial effect on fluid viscosity or density, special consideration will be applied to accommodate these changes.

403.3.1 Temperature may be measured by using one of the measuring devices listed below:

403.3.1.1 Liquid-in-glass thermometer,

403.3.1.2 Bimetallic dial thermometer,

403.3.1.3 Thermocouples,

403.3.1.4 Resistance Temperature Device (R.T.D.).

403.3.2 The liquid-in-glass and bimetallic dial thermometers are the least expensive and are direct reading. The thermocouple and resistance temperature devices require a potentiometric instrument for readout. The selection of which measuring device to use depends upon accuracy, cost, installation, and safety considerations.

403.3.3 Generally temperature variations are not crucial to test results. If temperature variations affect fluid characteristics, special considerations may be required.

403.4 *Capacity Measurement*

403.4.1 The measurement of capacity may be carried out by rate-of-flow meters, weighing, or volume methods. The reliability as well as the accuracy of weight or volume methods makes them preferable to rate-of-flow meters because the calibration of many rate-of-flow meters varies with viscosity.

403.4.2 By Weight: The measurement of capacity by weight depends upon the accuracy of the scale used and the measurement time. This method involves determining the change in the gross weight of a vessel on the suction or discharge of the pump in a given period of time.

403.4.3 By Volume: This method involves determining the volume of liquid being transferred to or from a vessel of known dimensions over a given period of time. Volume may be determined by measurement of the change in liquid level in a vessel. In this case, the liquid should be introduced into the tank with a diverter, and suitable baffles should be used in the tank to reduce swirls and eliminate surface effects.

403.4.4 By Venturi Meters, Orifice Meters, and Nozzles: Venturi meters, square-edged concentric orifice plates, and circular nozzles of the convergent type (both the submerged-flow and the free-discharge type) are acceptable instruments for field testing of centrifugal pumps. The installation and sizing of these meters should be in accordance with the manufacturer's recommendations. Selection of these meters should be based on accuracy, cost, installation, and safety considerations.

403.4.5 By Other Instruments: Rotameters, displacement meters, Doppler-effect meters and magnetic flow meters, and Pitot tubes may be used. However, they should be calibrated by a weight or volume technique using the test liquid at conditions of rate of flow and temperature to be encountered in the test. The instrument manufacturer should be consulted for test liquid effects.

403.5 *Speed Measurement:* The pump speed should be measured by any reliable revolution counter or a speed-measuring device, such as stroboscope, handheld tachometer, electronic counter with pulse generator or vibrating-reed tachometer.

403.6 *Power Measurement*

403.6.1 The majority of centrifugal pumps in the field are driven by a/c electrical motors. The power input to a direct-connected pump can be estimated within the accuracy of this procedure by using the electrical power in watts and multiplying by the operating point efficiency of the motor to determine the power input to the pump shaft.

403.6.2 When the overall efficiency of a pump and driver is to be determined, this procedure shall apply to the determination of the pump performance only. The appropriate test procedure for the driver should be referred to in determining driver input.

403.6.3 The power input to the motor can be measured at the motor terminals by any one of the following acceptable methods:

403.6.3.1 Polyphase wattmeter,

403.6.3.2 Single-phase wattmeter,

403.6.3.3 Voltmeter, ammeter and power factor where required.

403.6.4 Power input from other drivers, such as steam turbines or hydraulic motors, must be obtained in cooperation with the manufacturers of such equipment.