APPENDIX A FLOW MEASUREMENT

SCOPE

The water or brine (and steam) piping are generally not within the chiller manufacturer's scope of supply. AHRI 550/590 in conjunction with ASHRAE 30 require flow devices meeting an accuracy of 1% or better. Although field performance testing does not fall under this factory laboratory testing standard as AHRI 550/590 defines it, we do try wherever possible to adhere to this requirement to give our customers confidence in our methods. Devices meeting 1% accuracy requirement are generally full pipe flow devices, which are integral to the piping system. Unless dictated otherwise by contract, the Owner is responsible to provide and install calibrated flow measurement devices which will meet these accuracy requirements. These measurements are required for chilled water (or brine), condenser water and (if applicable) steam condensate flows.

Process flow measurement devices are critical in chiller performance testing, since flow is a direct factor in establishing chiller capacity, efficiency and also heat balance test validation. For steam turbine driven chillers the steam or condensate flow measurement also establishes power consumption. AHRI 550/590 and ASHRAE 30 standards on chiller performance testing require a 1% measurement accuracy (of reading at specified design point) for each flow measurement device.

INSTALLATION

All flow measurement devices are dependent upon a uniform velocity profile within the pipe. The placement of flow measurement devices within the piping system must be considered by the customer or their representative during the project design phase. Flow elements shall not be installed after control valves, or multiple elbows unless flow straightening vanes are utilized. Most insertion type and differential pressure flow elements require straight pipe runs of at least 20 pipe diameters upstream and 5 downstream to operate accurately without a flow straightening bundle. Most insertion type and differential pressure flow elements require straight pipe runs of at least 10 pipe diameters upstream and 5 downstream to operate accurately with a flow straightening bundle This can vary based upon piping configurations and device selection. The flow device manufacturer's recommendations must be followed for specific installation requirements. The flow element design and calibration shall be based upon the wall thickness or I.D. of the piping in which it will be installed.

CALIBRATION ACCURACY

Flow device manufacturer accuracy claims should not be taken at face value. The accuracy needs to be based on reading at design point, not full scale. The accuracy of secondary measurement or transmission devices should also be considered. Accuracy should not be confused with repeatability. To ensure accuracy, the flow device must be calibrated to an NIST (National Institute of Standards & Technology) traceable source. For most large flow meters this will require that a weight flow calibration test be performed on the actual flow device prior to installation.

INTERFACE TO TEST EQUIPMENT

In field testing, it is best that all data be taken simultaneously by a modern data acquisition system. The signal reading should be taken as close to the flow element source as possible, and not a retransmission from other sources. The Owner shall make allowance for the Test Engineer to make the necessary connections to the process ΔP taps via block valves, or direct to the electronics primary loop for electronic flow devices. When using a differential pressure device, such as an orifice, Venturi or Pitot tube, the flow calibration report must be provided to the Test Engineer. A calibrated differential pressure transmitter and flow characteristics can then be provided with the data acquisition system. For other types of flow devices, the calibration report and details on electronic signal type shall be provided to the Test Engineer. The electronic signal may be analog or pulse. When available current loop signals may be preferable.

PREFERRED FLOW MEASUREMENT DEVICES

Magnetic Flowtube flowmeters have been widely approved by AHRI for use in factory test facilities. JCI uses these meter types in our large tonnage test facilities and have received certification from AHRI for the facilities using them. JCI has experienced very good and repeatable results using these meters. The specification for use for fluid flow measurement is defined by ASME MFC-16-2007, Measurement of Fluid Flow in Closed Conduits be Means of Electromagnetic Flowmeters. JCI prefers the use of these devices for flow measurement since there is a history through factory use and calibration that these meters deviate very little from calibration to calibration and there are no moving parts to affect future calibration. Further, these flowmeters provide very good results when properly installed on any pipe size for which there is a flowmeter available.

Orifice Plates are listed in AHRI 550/590 test procedures. Their specification and use for flow measurement is defined by ASHRAE 41.8 .Standard Methods of Measurement of Flow of Liquids in Pipes Using Orifice Flowmeters. JCI has no objection to using an orifice for flow measurement as the characteristics are well established and there are no moving parts to affect future calibration. However, the high pumping costs associated with an orifice plate make it practical only for temporary installation, or for projects where a test bypass loop is part of the design.

Venturi Flow nozzles are listed in AHRI 550/590, with requirements defined by ASME standard MFC-3M, Measurement of Fluid Flow in Pipes Using Orifice, Nozzle and Venturi.. The Venturi is more expensive than an orifice, but has a lower pressure drop and reasonable pumping costs. For most permanent installations in large water flow lines a weight flow calibrated Venturi will provide accurate results.

Turbine Flowmeters are listed in AHRI 550/590 when they are applied per the requirements of ISA standard RP31.1 .Recommended Practice Specification, Installation and Calibration of Turbine Flowmeters. Axial turbine flow meters are recommended for use in measuring small pipe sizes. Axial turbine meters are preferred for steam condensate measurement on steam turbine driven chillers, and can be installed temporarily.

Insertion type turbine flow meters are generally not recommended by JCI for flow measurement to determine guaranteed capacity and efficiency because of the potential uncertainties for these meters. They are very dependent on installation location, depth, proximity to turbulence, etc. and on many occasions have proven to be less than reliable for this purpose.

Other types of flowmeters are not recognized by the AHRI 550/590 standard on chiller testing. The attached chart is intended for general comparison of the various types of flow metering which are available

Important Note
Should the Owner decide to use a meter with less accuracy than prescribed by AHRI 550/590, the test tolerances in capacity, power and heat balance must be relaxed by the difference in flow meter accuracy (JCI's expected accuracy based on past experiences as shown on the chart minus 1% allowable AHRI 550/590 flow accuracy will be added to the AHRI chiller tolerances).

Liquid Flow Metering Devices					*Accuracy, %	
Meter	Type	Pros (P) & Cons (C) associated		Signal type	Typical Mfg Claim	JCI expectation
Magnetic (ASME MFC-16M)	F	P	Needs less straight run of piping than other devices. High degree of accuracy when properly installed and calibrated. Very little pressure drop associated. No moving parts or pressure ports to clog.	Electronic	.25 to .5	0.5
Magnetic		C	Full pipe diameter device.			
Orifice Plate (ASHRAE 41.8)	F	P	AHRI/ASHRAE accepted. Established Theory. No moving parts. High accuracy when properly installed.	ΔP	1	1
		C	High ΔP equates to high pumping costs. System debris may clog pressure ports.			
Venturi (ASME MFC-3M)	F	P	AHRI/ASME accepted. Established theory. No moving parts. Lower pumping costs than orifice. High accuracy when weight flow calibrated and properly installed.	ΔP	.5 to 1	1
Venturi		C	System debris may clog pressure ports.			
Turbine Axial (ISA RP31.1)	F	P	AHRI/ISA accepted. Linear output provides good turn down.	Electronic	1	1
Axial turbine		C	Moving parts makes long reliability questionnable. Not feasiblefor large diameter piping.			
Turbine Insertion	I	P	Can be “hot tapped”. Lower initial costs.	Electronic	1	15
Insertion Turbine		C	Moving parts that are prone to reliability issues. Insertion devices are generally subject to installation methods, location, velocity profile changes, etc.			
Ultrasonic, Time Transit	N	P	Portable strap on device. Can be used when customer meters do not meet minimum requirements, there are no site meters or as a second meter.	Electronic	1 to 2	2.5
Ultrasonic, Time Transit		C	Installation reqiures fully developed flow profiles. System foaming/aeration will negatively affect funtionality of meter, may cause device not to function.			
Vortex Shedding & Target	I	P	Can be “hot tapped”. Lower initial costs.	Electronic	1.5	5
Vortex Shedding & Target		C	Insertion devices are generally subject to installation methods, location, velocity profile changes, etc.			
Pitot tube, Annubar	I	P	Can be “hot tapped”. Lower initial costs.	ΔP	1	5
Pitot tube, Annubar		C	Insertion devices are generally subject to installation methods, location, velocity profile changes, etc.			

Type: F = Full flow passes through device.   I = Insertion type of device   N = non intrusive

*Accuracy expectations are based upon proper installation per manufacturer’s recommendations and industry standard requirements. Improper installation or application may cause the inaccuracies to at least double. In some cases test data has shown the inaccuracies to increase to double digit values when installation requirements are not met.

This is intended as a general information source on the typical types of flow devices which may be applied to chiller tests/plant measuremnt. There are types of flowmeters not mentioned here including mass flowmeters, coriolis flowmeters, etc. which are often not applied in large flow piping requirements.

For further informational materials on flow devices, recommended readin: “Fundamentals of Flow Measurement” is available from the Instrument Society of America (ISA) by download from their website at www.isa.org.