

	ABSORPTION TEST PROCEDURE	
TECHNICAL DATA	Supersedes: NOTHING	Form 160.72-TD13 (307)

FIELD PERFORMANCE TEST PROCEDURE FOR LITHIUM BROMIDE ABSORPTION CHILLER PACKAGES

YORK offers to conduct a Field Performance Test for chilling systems. The test requirements may be detailed by project specifications or quoted as part of a project bid package for new equipment. In such testing, YORK's Test Group (YTG) will be responsible only for testing equipment manufactured by YORK and installed, as recommended by YORK.

TEST STANDARDS

Air-Conditioning & Refrigeration Institute Standard ARI 560 details rating, certification and testing of water chilling packages. Field testing does not fall within the certification program. However, YORK does follow ARI 560 guidelines in rating the chilling systems. The test procedures detailed by ARI 560 appendix C will be followed as closely as practical for the Field test. It should be recognized that some of the tolerances defined by ARI 560 may need to be relaxed due to site conditions. For instance:

- It may be difficult to obtain 3 sets of data at 5 minute intervals if the load conditions are not steady.
- Flow measurement may be difficult dependent on the device and measurement location. See Appendix A for discussion of tolerance adjustments based on expected accuracies.
- It may be necessary to adjust the chilled water flow rate beyond $\pm 5\%$ if the return temperature is not at design (this may affect chiller lbs/hr/TR).
- Heat balance may exceed tolerance due to inaccuracies of site test equipment. It may be desired to average the capacities measured by chilled water and cooling water heat measurements.
- It may be difficult to control design entering condenser water temperature within 0.5°F.
- Fouling factors on site may be difficult to determine or control.

American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. standards:

- ANSI/ASHRAE 30 Method of Testing Liquid-Chilling Packages is referenced by ARI for flow measurement. This standard can be used for field testing and basically describes the same test procedures as ARI 550. But, this standard does not cover chiller rating guidelines.
- ANSI/ASHRAE 41.1 Standard Method for Temperature Measurement applies to temperature measurement techniques.
- ANSI/ASHRAE 41.8 Standard Methods of Measurement of Flow of Liquids in Pipes Using Orifice Flowmeters.

GENERAL POLICY

- 1) Field Test(s) shall be conducted in accordance with ARI 560 Standard (latest edition in place when the chiller is ordered). All YORK Unit Performance Data are based on ARI Standard 560, with all applicable tolerances. For the specified operating conditions of a project, the tolerance will typically be in the range of $\pm 5.0\%$ at full-load operating conditions, with increasingly broader tolerances at reduced load conditions. Where narrower tolerances are desired, they must be clearly included in the project specifications, and accounted for in the quotation. The quotation ratings must reflect adequate performance safety margins to account for the special tolerance. Owners or Consultants who specify narrower than ARI tolerance should understand that this is increasing the cost of the chiller.

- 2) The following test instrumentation (see also FIG. 1 thru 3, and Tables 1 thru 3) will be used for YORK Test Group conducted tests:
 - a) Flows: The Owner shall supply all Liquid Flow meters. The flow meters shall be of the type required to comply with ARI Standards. Refer to Appendix A for further guidance on flow measurement devices. Design and calibration data shall be made available to YTG to allow input to YTG's Field Data Acquisition System. Should the Owner elect to utilize any meter other than recognized by ARI and ASHRAE, YORK reserves the right to either accept or reject this meter selection. In the event that YORK rejects this meter selection, YORK will enter into negotiations with the appropriate YORK and Owner representatives to determine the appropriate solution and possible tolerance increase based on meter selection and installation location. This will be driven by expected accuracy based on past experiences.

 - b) Temperatures: Resistance Temperature Detectors, or RTDs, shall be provided by YTG that are National Institutes of Standards & Technology (NIST) traceable and meet the requirements of ARI Standards for all water and refrigerant measurements between the ranges of 30 to 150 Degrees Fahrenheit (special calibrations will be done for low temperature brine chillers). Temperatures above 150 Degrees Fahrenheit will be measured by Thermocouples using NIST Curves. The Owner shall supply temperature wells in all chilled/cooling piping. The wells shall accept ¼ inch OD RTDs extending to the center of the pipes. The wells shall be installed in a vertical orientation to enable filling with a liquid heat conducting material. The wells shall be installed about six pipe diameters from the exits of the chilled/cooling shell flanges to assure good fluid mixture at the point of measurement.

 - c) Pressures: Pressure transducers shall be provided by YTG that are NIST traceable and meet the requirements of all ARI Standards. The Owner shall supply new or existing connections for evaporator and condenser refrigerant-side and water-side pressure measurements.

 - d) Work input shall be defined as Steam Fired, Natural Gas/Oil Fired and Hotwater Fired. The determination of actual work input (btu/hr) to the chiller package shall be determined as defined in ARI 560.

 - e) Steam and/or hot water consumption will be measured utilizing calibrated turbine flowmeters that are NIST traceable and meets the requirements of all ARI standards. Provisions should be made on the condensate overboard piping to install this flowmeter. Three 2" full port ball valves should be installed per the installation drawing included in this procedure.

 - f) For gas/oil fired units, the customer shall be responsible for providing ARI/ASHRAE compliant natural gas or oil flowmeters. Design and calibration data shall be made available to YTG to allow input to YTG's Field Data Acquisition System. Should the Owner elect to utilize any meter other than recognized by ARI and ASHRAE, YORK reserves the right to either accept or reject this meter selection. In the event that YORK rejects this meter selection, YORK will enter into negotiations with the appropriate YORK and Owner representatives to determine the appropriate solution and possible tolerance increase based on meter selection and installation location. This will be driven by expected accuracy based on past experiences.



YTG supplied instrumentation is calibrated to NIST traceable standards at regular intervals. Specifications which require before and after test calibrations will incur increased test costs.

- 3) All data from RTDs, pressure transducers, gages, electrical measurements, and flow meters, should be collected by a high accuracy data acquisition system. When YORK is performing the test, YTG will utilize a high accuracy Data Acquisition System which is linked to display data on a laptop PC and record on a portable printer. The PC will update all recordings about every 10 seconds and continuously indicate all measurements as well as capacity, power consumption, and heat balance through Excel software. Upon stabilization, the printer will make a record of the test.

STABILITY DEFINITION

Stability of flow shall be defined as:

A stable conditions exists when the volume of water over time (gpm) remains within 2% of the design flow rate and cycles peak to peak in no less than 1 minute.

Stability of temperature shall be defined as:

A stable condition exists when the temperature of water over time ($^{\circ}\text{F}/\text{min}$) remains within $.5^{\circ}\text{F}$ of design temperature and moves no more than $.1^{\circ}\text{F}$ per 1 minute on average with a 20 minute span peak to peak.

This stability allows for stable readings that can provide the 10 minute window for data collection that ARI mandates.

- 4) ARI test procedures require that a tube side fouling factor of 0.000 be assumed if heat exchanger surfaces are cleaned just prior to test. Temperature penalty adjustments to compensate for the chiller rated scaling for both evaporator and condenser would then be performed. But, for field performance tests, the job site water treatments do not meet laboratory cleanliness, nor are the tubes completely clean by the time the test is conducted.



Recognizing that tube-side fouling will begin within hours of commercial operation, full design fouling will be assumed for the test. This means there will be no water temperature corrections for clean tube fouling as detailed by ARI 560, which apply only to new and unused tubes in a factory or laboratory test environment.

However, should fouling at time of test be above design as measured by heat exchanger small differences, YORK reserves the right to request Owner to perform tube cleaning (not in YORK scope). Evaporator approach will be determined by comparison of the liquid refrigerant temperature at the refrigerant pump discharge to the leaving chilled water temperature. Condenser approach shall be determined by comparison of the condenser refrigerant outlet temperature to the leaving cooling water temperature. This approach temperature can be used to estimate the water side fouling condition.

If tube cleaning is requested by YORK due to excessive fouling, the preferred tube cleaning to achieve zero fouling must consist of brush cleaning followed by acid cleaning. If this is done, and performance tests are run immediately, water temperature corrections would be calculated per ARI 560 to simulate a zero fouling clean tube condition.

Alternatively, if only a brush cleaning OR acid tube cleaning method is to be done (if preferred by Owner due to costs), experience has shown that a true tube condition of zero fouling is not likely. With this one-step-cleaning mode, tube-side fouling would be assumed .0001 ARI standard for the evaporator, and .00025 ARI standard for condenser water. Temperature corrections to simulate the difference (if any) between chiller rated / specified fouling and the preceding ARI standard values would be utilized for the test.

- 5) After all operating conditions are adjusted for design conditions and the chiller tested for proper refrigerant charge and all system valve settings adjusted for proper operation and positioning, a state of readiness can be declared for the Field Performance Test.
- 6) After declaration of the state of readiness, the system should be allowed to operate overnight, under the supervision of the Owner's site personnel, at the normal plant operations requirements. If possible, load shedding of other equipment, should be incorporated to keep the proposed test equipment as fully loaded as possible during night operations, so that on the day of the test the unit tested will require minimum stabilization to test conditions
- 7) On the day of the test, the test unit will have been operating overnight and the time to attain stabilized test conditions will be minimized. To attain test conditions, design flow rate will be checked and adjusted to design values. The site operators will then be requested to shed loads to maintain design entering chilled water and condenser water temperatures. Hopefully, these can be attained within a few hours. Three sets of readings taken at 5-minute intervals of temperatures, flow and power readings will fulfill the requirements of ARI 560. Heat balance of the test runs will be checked during the test and, if within 5%, compliance with requirements of the standard will be met, the test will be concluded and a report issued.
- 8) Part load Field Performance Tests may be requested at additional cost. YORK publishes part load curves for typical installations. Steady state conditions are sometime difficult to achieve whereby conditions maintained per the Test Engineers request should provide suitable information. Allowable tolerances as specified per ARI 560.
- 9) After successful test compliance with the standard, and heat balance verification, a report of the system Field Performance Test will be prepared. YORK will provide a copy of test report to the individual designated in the Contract Specifications.

CUSTOMER/OWNER RESPONSIBILITY

The following is a list of items that the Customer/Owner must retain responsibility for successful completion of the required performance and/or sound testing. The Customer should be considered an essential part of the test team. Successful acceptance of the test will not be achieved unless the Customer is engaged and involved in supporting the test. The Customer should:

- Provide a single point of responsibility, “The Customer Representative”**

- Schedule chiller availability**

- Provide stable operating conditions**

The customer/owner shall be responsible to provide the load for the test chiller, shall control the water flows and temperatures to the design conditions as specified by the performance and/or sound Test Engineer.

A YORK technician shall monitor the system operating conditions for the duration of the performance and/or sound test. If the chiller operating conditions vary substantially from the stable conditions as defined above, all collection of official data will cease until the required conditions can be maintained.

- Assume responsibility costs of all operating utilities during the testing**

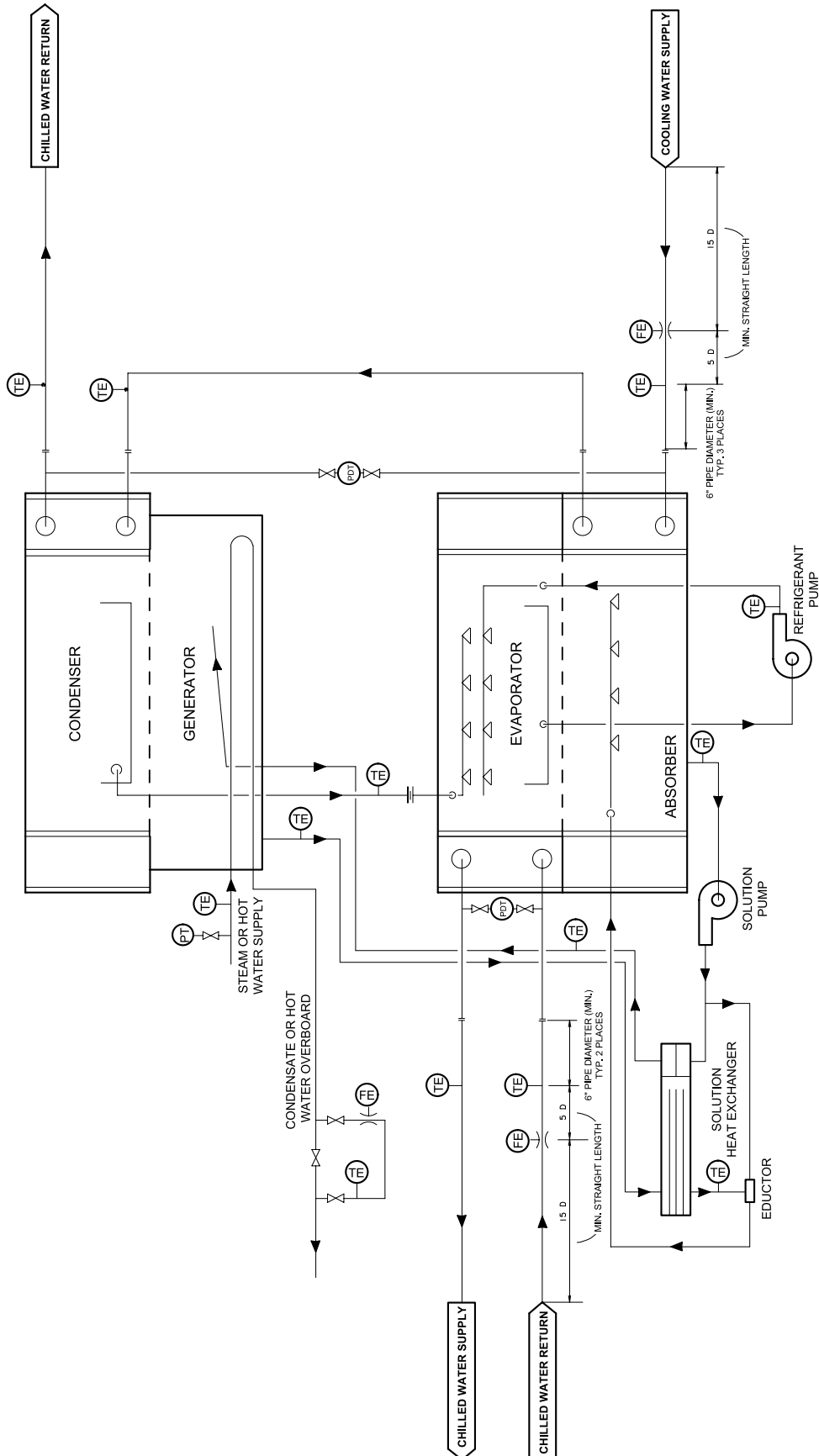
Contracted testing delays or reschedules resulting from equipment supplied by others, will be charged on per-diem basis.

- Understand the implications of less than ideal testing conditions.**

Customer should accept that less than ideal test instrumentation selection, instrumentation installation and or system stability will yield less than ideal tolerance on accuracy and some level of relaxation of the test results may be required

- Accept the test results and report**

YIA PIPING AND INSTRUMENTATION

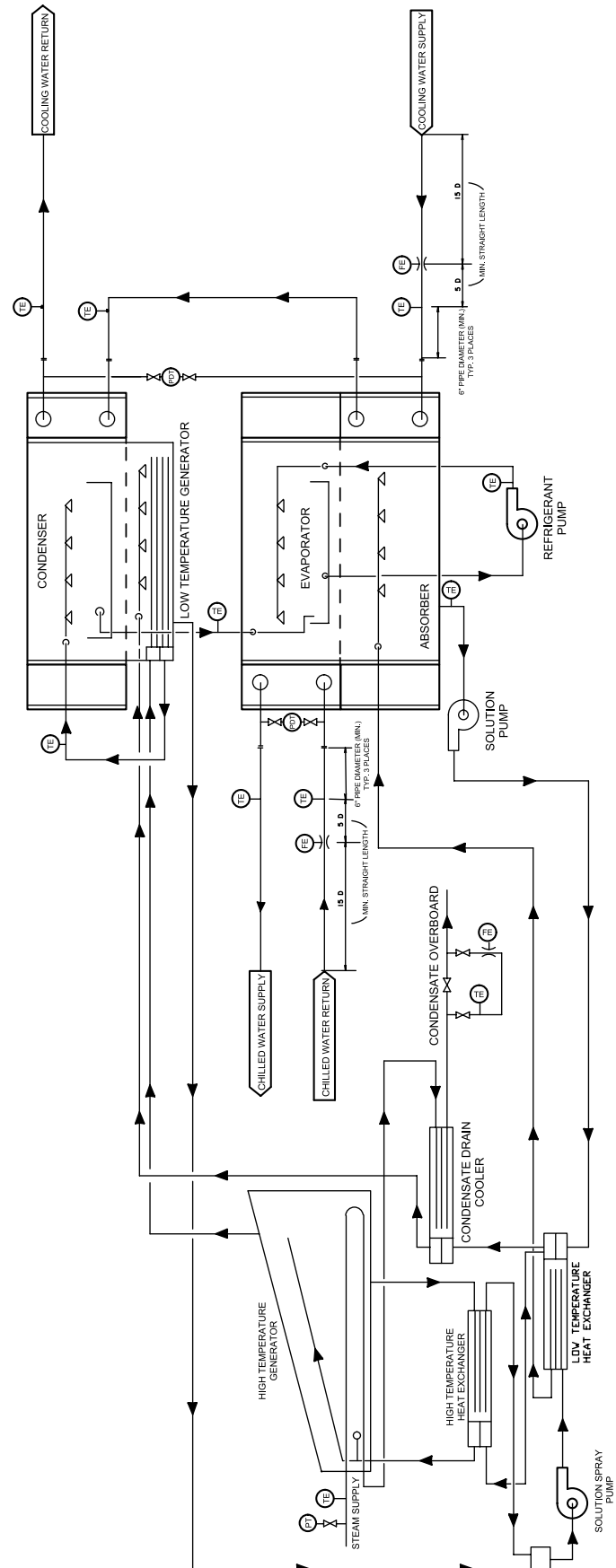


NOTE: Refer to project specifications and plans for instrumentation scope of supply.

FIG. 1 - YIA PIPING AND INSTRUMENTATION DIAGRAM

LD12650

YPC STEAM PIPING AND INSTRUMENTATION

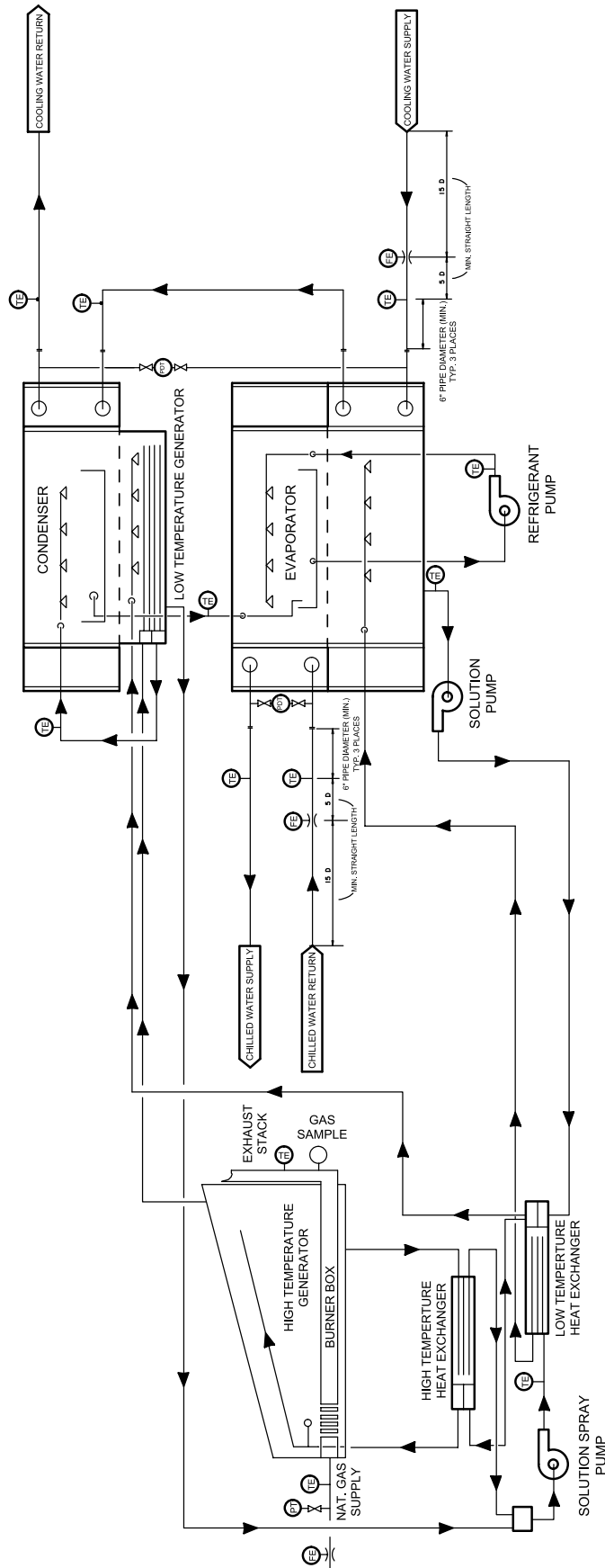


NOTE: Refer to project specifications and plans for instrumentation scope of supply.

FIG. 2 - YPC STEAM PIPING AND INSTRUMENTATION DIAGRAM

LD12654

YPC GAS PIPING AND INSTRUMENTATION



NOTE: Refer to project specifications and plans for instrumentation scope of supply.

FIG. 3 - YPC GAS PIPING AND INSTRUMENTATION DIAGRAM

LD12655

APPENDIX A - FLOW MEASUREMENT

Process flow measurement devices are critical in chiller performance testing, since flow is a direct factor in establishing chiller capacity and also heat balance test validation. For steam turbine driven chillers the steam or condensate flow measurement also establishes power consumption. ARI 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.

SCOPE

The water or brine (and steam) piping are generally not within the chiller manufacturer's scope of supply. 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.

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 Consultant 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 DP 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 the pulse signals may be preferable.

PREFERRED FLOW MEASUREMENT DEVICES

Orifice Plates are recognized by ARI 560 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”. YORK prefers 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 also recognized by ARI 560, 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 recognized by ARI 560 when they are applied per 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 York for large flow lines unless they can be calibrated in the full line size and piping configuration.

Other types of flowmeters are not recognized by the ARI 560 standard on chiller testing. The attached chart is intended for general comparison of the various types of flow metering which are available. Should the Owner decide to use a meter with less accuracy than prescribed by ARI 560, the test tolerances in capacity, power and heat balance must be adjusted upwards by the difference in flow meter accuracy (YORK’s expected accuracy based on past experiences as shown on the chart minus 1% ARI flow accuracy will be added to the ARI chiller tolerances).

APPENDIX A - FLOW MEASUREMENT

Liquid Flow Metering Devices				*Accuracy, %	
Meter	Type	Pros (P) & Cons (C) associated	Signal	Typical Mfg Claim	York's Expectation
Orifice Plate (ASHRAE 41.8)	F	P: ARI/ASHRAE accepted. Established theory. No moving parts.	DP	1	1
		C: High DP equates to high pump costs.			
Venturi (ASME MFC-3M)	F	P: ARI/ASME accepted. Established theory. No moving parts. Lower pumping costs than orifice. Highly accurate when weight flow calibrated and properly installed.	DP	.5 to 1	1
		C: Higher cost than orifice. Full pipe diameter device.			
Turbine, Axial (ISA RP31.1)	F	P: ARI/ISA accepted. Linear output provides good turn down.	Electronic	1	1
		C: Moving parts make long term reliability questionable. Not feasible for large diameter pipes.			
Turbine, Insertion	I	P: Lower cost. Linear output. Can be hot tapped through a valve.	Electronic	1	3
		C: Moving parts. Insertion devices subject to error due to pipe installation methods, velocity profile changes.			
Magnetic	F	P: Accurate when properly calibrated. Needs less straight run of pipe than other methods.	Electronic	¼ to ½	1.5
		C: Expensive, full pipe diameter device.			
Ultrasonic, Time Transit	N	P: Portable strap on device. Can be used when nothing else is available, or as a second flow measurement.	Electronic	1 to 2	3
		C: Calibration is often based on other pipe sizes or installation. Accuracy is questionable.			
Vortex Shedding & Target	I	P: Low cost. Can be hot tapped.	Electronic	1.5	5
		C: Insertion devices subject to installation errors.			
Pitot Tube (Annubar)	I	P: Low cost. Can be hot tapped.	DP	1	5
		C: Insertion devices subject to installation errors. Typically not offered with weight flow calibration.			

Type: F = Full flow passes through element. I = Insertion type 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.

This is intended as general information on the typical types of flow devices which may be applied to chiller tests. There are other types of flow meters including mass flow meters which are not often used for large water flow applications.

For further informational materials on flow devices, recommend reading: "Fundamentals of Flow Measurement" is available from Instrument Society of America (ISA) by download from their website at www.isa.org.

APPENDIX B - INSTRUMENTATION INSTALLATION

YIA INSTRUMENTATION INSTALLATION REQUIREMENTS							
TYPE OF MEASUREMENT	DESCRIPTION	INSTALLATION REQUIREMENTS	INSTALLATION RESPONSIBILITY	NUMBER OF MEASUREMENT POINTS	INSTRUMENT SUPPLIER	INSTRUMENT TYPE	CALIBRATION RESPONSIBILITY
Temperature	Evaporator inlet/outlet water temperature wells	The thermal wells shall accept 1/4" OD RTDs extending to the center of the pipes. The wells shall be installed in a vertical orientation to enable filling with a liquid heat conducting material. The wells shall be installed about six pipe diameters from the entrance and exit points of the chilled shell flanges to assure good fluid mixture at the point of measurement.	Customer	2	YORK	RTD	YORK
Temperature	Absorber/Condenser inlet/outlet water temperature wells	The thermal wells shall accept 1/4" OD RTDs extending to the center of the pipes. The wells shall be installed in a vertical orientation to enable filling with a liquid heat conducting material. The wells shall be installed about six pipe diameters from the entrance and exit points of the cooling shell flanges to assure good fluid mixture at the point of measurement.	Customer	3	YORK	RTD	YORK
Temperature	Steam/Hot Water Supply Temperature well	The thermal well shall accept a 1/8" OD TC Probe extending into the center of the flow stream. The well shall be installed in a vertical orientation to enable filling with a heat conducting compound. This well shall be installed prior to the steam supply valve.	Customer	1	YORK	TC	YORK
Temperature	Condensate/Leaving Hot Water Temperature well	The thermal well shall accept a 1/8" OD TC Probe extending into the center of the flow stream. The well shall be installed in a vertical orientation, if possible, to enable filling with a heat conducting compound. This well shall be installed as close as possible to the "flowmeter" in the condensate line, but not interfere with the flow stream.	Customer	1	YORK	TC	YORK

YIA INSTRUMENTATION INSTALLATION REQUIREMENTS							
TYPE OF MEASUREMENT	DESCRIPTION	INSTALLATION REQUIREMENTS	INSTALLATION RESPONSIBILITY	NUMBER OF MEASUREMENT POINTS	INSTRUMENT SUPPLIER	INSTRUMENT TYPE	CALIBRATION RESPONSIBILITY
Temperature	Evaporator and Condenser liquid refrigerant temperature wells	The thermal wells shall accept 1/6" OD RTD's extending to the center of the pipes. The wells shall be installed in a vertical orientation to enable filling with a liquid heat conducting material. Limits of the piping arrangements may make it necessary to install the Thermocouple on the external pipe wall and insulate the probe. Since these measurements are reference only, this will not directly affect the accuracy of the performance data.	YORK	2	YORK	RTD	YORK
Temperature	Weak solution out of Absorber	The thermal wells shall accept 1/8" OD Thermocouples extending to the center of the pipes. The wells shall be installed in a vertical orientation to enable filling with a liquid heat conducting material. Limits of the piping arrangements may make it necessary to install the Thermocouple on the external pipe wall and insulate the probe. Since these measurements are reference only, this will not directly affect the accuracy of the performance data.	YORK	1	YORK	TC	YORK
Temperature	Refrigerant vapor entering condenser	The thermal wells shall accept 1/8" OD Thermocouples extending to the center of the pipes. The wells shall be installed in a vertical orientation to enable filling with a liquid heat conducting material. Limits of the piping arrangements may make it necessary to install the Thermocouple on the external pipe wall and insulate the probe. Since these measurements are reference only, this will not directly affect the accuracy of the performance data.	YORK	1	YORK	TC	YORK
Pressure	Steam Supply pressure connection valve (steam fired only)	The steam supply piping shall have a valved connection point with 1/4" pipe thread and a siphon tube at the inlet to the trip and throttle valve to the turbine.	Customer	1	YORK	Pressure Transducer	YORK

YIA INSTRUMENTATION INSTALLATION REQUIREMENTS							
TYPE OF MEASUREMENT	DESCRIPTION	INSTALLATION REQUIREMENTS	INSTALLATION RESPONSIBILITY	NUMBER OF MEASUREMENT POINTS	INSTRUMENT SUPPLIER	INSTRUMENT TYPE	CALIBRATION RESPONSIBILITY
Pressure	Evaporator Water Box Differential Pressure connection valves	There shall be a vertical up or horizontal valved connection at the inlet and outlet water nozzles of the shell water boxes. These connections shall be 1/4" pipe thread and located prior to the first elbow and flange if practical.	Customer	2 per shell	YORK	Differential Pressure Transducer	YORK
Pressure	Absorber/Condenser Water Box Differential Pressure connection valves	There shall be a vertical up or horizontal valved connection at the inlet and outlet water nozzles of the shell water boxes. These connections shall be 1/4" pipe thread and located prior to the first elbow and flange if practical.	Customer	2 per shell	YORK	Differential Pressure Transducer	YORK
Flow	Evaporator flow meter	The flow meters shall be of the type required to comply with ARI Standards. Refer to Appendix A in the York field Performance Test Procedure for further guidance on selection flow measurement devices. Design and calibration data shall be made available to YTG to allow input to YTG's Field Data Acquisition System. These devices shall be installed with unobstructed straight run piping with a minimum of 15 pipe diameters upstream of the flowmeter and 5 pipe diameters downstream of the flowmeter. The upstream length can be shortened to 10 pipe diameters with the use of a flow straightening bundle. Pipe diameters is defined as the diameter of the flow meter and the pipe in which the flow is to be measured. Both shall be the same diameter.	Customer	1 per loop	Customer	To be determined by the customer	Customer

YIA INSTRUMENTATION INSTALLATION REQUIREMENTS							
TYPE OF MEASUREMENT	DESCRIPTION	INSTALLATION REQUIREMENTS	INSTALLATION RESPONSIBILITY	NUMBER OF MEASUREMENT POINTS	INSTRUMENT SUPPLIER	INSTRUMENT TYPE	CALIBRATION RESPONSIBILITY
Flow	Condenser flow meter	The flow meters shall be of the type required to comply with ARI Standards. Refer to Appendix A in the York field Performance Test Procedure for further guidance on selection flow measurement devices. Design and calibration data shall be made available to YTG to allow input to YTG's Field Data Acquisition System. These devices shall be installed with unobstructed straight run piping with a minimum of 15 pipe diameters upstream of the flowmeter and 5 pipe diameters downstream of the flowmeter. The upstream length can be shortened to 10 pipe diameters with the use of a flow straightening bundle. Pipe diameters is defined as the diameter of the flow meter and the pipe in which the flow is to be measured. Both shall be the same diameter.	Customer	1 per loop	Customer	To be determined by the customer	Customer
Flow	Condensate/Hot Water flow meter	Condensate/Hot Water shall be measured in the same manner as the chiller water flow rates. The valves shall be 2" full port ball valves rated for the system operating conditions. These valves shall be installed on the outlet side of the generator and be in the same arrangement as shown in FIG. 1. See FIG. 1 for valve location details.	YORK	1 per loop	YORK	Axial turbine	YORK

YPC STEAM INSTRUMENTATION INSTALLATION REQUIREMENTS

TYPE OF MEASUREMENT	DESCRIPTION	INSTALLATION REQUIREMENTS	INSTALLATION RESPONSIBILITY	NUMBER OF MEASUREMENT POINTS	INSTRUMENT SUPPLIER	INSTRUMENT TYPE	CALIBRATION RESPONSIBILITY
Temperature	Evaporator inlet/outlet water temperature wells	The thermal wells shall accept 1/4" OD RTDs extending to the center of the pipes. The wells shall be installed in a vertical orientation to enable filling with a liquid heat conducting material. The wells shall be installed about six pipe diameters from the entrance and exit points of the chilled shell flanges to assure good fluid mixture at the point of measurement.	Customer	2	YORK	RTD	YORK
Temperature	Absorber/Condenser inlet/outlet water temperature wells	The thermal wells shall accept 1/4" OD RTDs extending to the center of the pipes. The wells shall be installed in a vertical orientation to enable filling with a liquid heat conducting material. The wells shall be installed about six pipe diameters from the entrance and exit points of the cooling shell flanges to assure good fluid mixture at the point of measurement.	Customer	3	YORK	RTD	YORK
Temperature	Steam Supply Temperature well	The thermal well shall accept a 1/8" OD TC Probe extending into the center of the flow stream. The well shall be installed in a vertical orientation to enable filling with a heat conducting compound. This well shall be installed prior to the steam supply valve.	Customer	1	YORK	TC	YORK
Temperature	Condensate Temperature well	The thermal well shall accept a 1/8" OD TC Probe extending into the center of the flow stream. The well shall be installed in a vertical orientation, if possible, to enable filling with a heat conducting compound. This well shall be installed as close as possible to the "flowmeter" in the condensate line, but not interfere with the flow stream.	Customer	1	YORK	TC	YORK

YPC STEAM INSTRUMENTATION INSTALLATION REQUIREMENTS							
TYPE OF MEASUREMENT	DESCRIPTION	INSTALLATION REQUIREMENTS	INSTALLATION RESPONSIBILITY	NUMBER OF MEASUREMENT POINTS	INSTRUMENT SUPPLIER	INSTRUMENT TYPE	CALIBRATION RESPONSIBILITY
Temperature	Evaporator and Condenser liquid refrigerant temperature wells	The thermal wells shall accept 1/8" OD Thermocouples extending to the center of the pipes. The wells shall be installed in a vertical orientation to enable filling with a liquid heat conducting material. Limits of the piping arrangements may make it necessary to install the Thermocouple on the external pipe wall and insulate the probe. Since these measurements are reference only, this will not directly affect the accuracy of the performance data.	YORK	2	YORK	TC	YORK
Temperature	Weak solution out of Absorber	The thermal wells shall accept 1/8" OD Thermocouples extending to the center of the pipes. The wells shall be installed in a vertical orientation to enable filling with a liquid heat conducting material. Limits of the piping arrangements may make it necessary to install the Thermocouple on the external pipe wall and insulate the probe. Since these measurements are reference only, this will not directly affect the accuracy of the performance data.	YORK	1	YORK	TC	YORK
Temperature	Refrigerant vapor entering condenser	The thermal wells shall accept 1/8" OD Thermocouples extending to the center of the pipes. The wells shall be installed in a vertical orientation to enable filling with a liquid heat conducting material. Limits of the piping arrangements may make it necessary to install the Thermocouple on the external pipe wall and insulate the probe. Since these measurements are reference only, this will not directly affect the accuracy of the performance data.	YORK	1	YORK	TC	YORK
Pressure	Steam Supply pressure connection valve	The steam supply piping shall have a valved connection point with 1/4" pipe thread and a siphon tube at the inlet to the trip and throttle valve to the turbine.	Customer	1	YORK	Pressure Transducer	YORK

YPC STEAM INSTRUMENTATION INSTALLATION REQUIREMENTS

TYPE OF MEASUREMENT	DESCRIPTION	INSTALLATION REQUIREMENTS	INSTALLATION RESPONSIBILITY	NUMBER OF MEASUREMENT POINTS	INSTRUMENT SUPPLIER	INSTRUMENT TYPE	CALIBRATION RESPONSIBILITY
Pressure	Evaporator Water Box Differential Pressure connection valves	There shall be a vertical up or horizontal valved connection at the inlet and outlet water nozzles of the shell water boxes. These connections shall be 1/4" pipe thread and located prior to the first elbow and flange if practical.	Customer	2 per shell	YORK	Differential Pressure Transducer	YORK
Pressure	Absorber/Condenser Water Box Differential Pressure connection valves	There shall be a vertical up or horizontal valved connection at the inlet and outlet water nozzles of the shell water boxes. These connections shall be 1/4" pipe thread and located prior to the first elbow and flange if practical.	Customer	2 per shell	YORK	Differential Pressure Transducer	YORK
Flow	Evaporator flow meter	The flow meters shall be of the type required to comply with ARI Standards. Refer to Appendix A in the York field Performance Test Procedure for further guidance on selection of flow measurement devices. Design and calibration data shall be made available to YTG System. These devices shall be installed with unobstructed straight run piping with a minimum of 15 pipe diameters upstream of the flowmeter and 5 pipe diameters downstream of the flowmeter. The upstream length can be shortened to 10 pipe diameters with the use of a flow straightening bundle. Pipe diameters is defined as the diameter of the flow meter and the pipe in which the flow is to be measured. Both shall be the same diameter.	Customer	1 per loop	Customer	To be determined by the customer	Customer

YPC STEAM INSTRUMENTATION INSTALLATION REQUIREMENTS							
TYPE OF MEASUREMENT	DESCRIPTION	INSTALLATION REQUIREMENTS	INSTALLATION RESPONSIBILITY	NUMBER OF MEASUREMENT POINTS	INSTRUMENT SUPPLIER	INSTRUMENT TYPE	CALIBRATION RESPONSIBILITY
Flow	Condenser flow meter	The flow meters shall be of the type required to comply with ARI Standards. Refer to Appendix A in the York field Performance Test Procedure for further guidance on selection flow measurement devices. Design and calibration data shall be made available to YTG to allow input to YTG's Field Data Acquisition System. These devices shall be installed with unobstructed straight run piping with a minimum of 15 pipe diameters upstream of the flowmeter and 5 pipe diameters downstream of the flowmeter. The upstream length can be shortened to 10 pipe diameters with the use of a flow straightening bundle. Pipe diameters is defined as the diameter of the flow meter and the pipe in which the flow is to be measured. Both shall be the same diameter.	Customer	1 per loop	Customer	To be determined by the customer	Customer
Flow	Condensate flow meter	Condensate shall be measured in the same manner as the chiller water flow rates. York shall provide detailed installation instructions for pipe size once the design condensate flow rate is known.	YORK	1 per loop	YORK	Axial turbine	YORK

YPC GAS INSTRUMENTATION INSTALLATION REQUIREMENTS							
TYPE OF MEASUREMENT	DESCRIPTION	INSTALLATION REQUIREMENTS	INSTALLATION RESPONSIBILITY	NUMBER OF MEASUREMENT POINTS	INSTRUMENT SUPPLIER	INSTRUMENT TYPE	CALIBRATION RESPONSIBILITY
Temperature	Evaporator inlet/outlet water temperature wells	The thermal wells shall accept ¼" OD RTDs extending to the center of the pipes. The wells shall be installed in a vertical orientation to enable filling with a liquid heat conducting material. The wells shall be installed about six pipe diameters from the entrance and exit points of the chilled shell flanges to assure good fluid mixture at the point of measurement.	Customer	2	YORK	RTD	YORK
Temperature	Absorber/Condenser inlet/outlet water temperature wells	The thermal wells shall accept ¼" OD RTDs extending to the center of the pipes. The wells shall be installed in a vertical orientation to enable filling with a liquid heat conducting material. The wells shall be installed about six pipe diameters from the entrance and exit points of the cooling shell flanges to assure good fluid mixture at the point of measurement.	Customer	3	YORK	RTD	YORK
Temperature	Steam Supply Temperature well	The thermal well shall accept a 1/8" OD TC Probe extending into the center of the flow stream. The well shall be installed in a vertical orientation to enable filling with a heat conducting compound. This well shall be installed prior to the steam supply valve.	Customer	1	YORK	TC	YORK

YPC GAS INSTRUMENTATION INSTALLATION REQUIREMENTS							
TYPE OF MEASUREMENT	DESCRIPTION	INSTALLATION REQUIREMENTS	INSTALLATION RESPONSIBILITY	NUMBER OF MEASUREMENT POINTS	INSTRUMENT SUPPLIER	INSTRUMENT TYPE	CALIBRATION RESPONSIBILITY
Temperature	Condensate Temperature well	The thermal well shall accept a 1/8" OD TC Probe extending into the center of the flow stream. The well shall be installed in a vertical orientation, if possible, to enable filling with a heat conducting compound. This well shall be installed as close as possible to the "flowmeter" in the condensate line, but not interfere with the flow stream.	Customer	1	YORK	TC	YORK
Temperature	Evaporator and Condenser liquid refrigerant temperature wells	The thermal wells shall accept 1/8" OD Thermocouples extending to the center of the pipes. The wells shall be installed in a vertical orientation to enable filling with a liquid heat conducting material. Limits of the piping arrangements may make it necessary to install the Thermocouple on the external pipe wall and insulate the probe. Since these measurements are reference only, this will not directly affect the accuracy of the performance data.	YORK	2	YORK	TC	YORK
Temperature	Weak solution out of Absorber	The thermal wells shall accept 1/8" OD Thermocouples extending to the center of the pipes. The wells shall be installed in a vertical orientation to enable filling with a liquid heat conducting material. Limits of the piping arrangements may make it necessary to install the Thermocouple on the external pipe wall and insulate the probe. Since these measurements are reference only, this will not directly affect the accuracy of the performance data.	YORK	1	YORK	TC	YORK

YPC GAS INSTRUMENTATION INSTALLATION REQUIREMENTS							
TYPE OF MEASUREMENT	DESCRIPTION	INSTALLATION REQUIREMENTS	INSTALLATION RESPONSIBILITY	NUMBER OF MEASUREMENT POINTS	INSTRUMENT SUPPLIER	INSTRUMENT TYPE	CALIBRATION RESPONSIBILITY
Temperature	Refrigerant vapor entering condenser	The thermal wells shall accept 1/8" OD Thermocouples extending to the center of the pipes. The wells shall be installed in a vertical orientation to enable filling with a liquid heat conducting material. Limits of the piping arrangements may make it necessary to install the Thermocouple on the external pipe wall and insulate the probe. Since these measurements are reference only, this will not directly affect the accuracy of the performance data.	YORK	1	YORK	TC	YORK
Temperature	Exhaust Stack Temperature	This shall be a valved connection that will allow insertion of 1/8" OD Thermocouple extending to the center of the stack.	Customer	1	YORK	TC	YORK
Pressure	Natural Gas Supply pressure connection valve	The gas supply piping shall have a valved connection point with 1/4" pipe thread.	Customer	1	YORK	Pressure Transducer	YORK
Pressure	Evaporator Water Box Differential Pressure connection valves	There shall be a vertical up or horizontal valved connection at the inlet and outlet water nozzles of the shell water boxes. These connections shall be 1/4" pipe thread and located prior to the first elbow and flange if practical.	Customer	2 per shell	YORK	Differential Pressure Transducer	YORK
Pressure	Absorber/Condenser Water Box Differential Pressure connection valves	There shall be a vertical up or horizontal valved connection at the inlet and outlet water nozzles of the shell water boxes. These connections shall be 1/4" pipe thread and located prior to the first elbow and flange if practical.	Customer	2 per shell	YORK	Differential Pressure Transducer	YORK

YPC GAS INSTRUMENTATION INSTALLATION REQUIREMENTS							
TYPE OF MEASUREMENT	DESCRIPTION	INSTALLATION REQUIREMENTS	INSTALLATION RESPONSIBILITY	NUMBER OF MEASUREMENT POINTS	INSTRUMENT SUPPLIER	INSTRUMENT TYPE	CALIBRATION RESPONSIBILITY
Miscellaneous	Exhaust Stack Gas Property Port	This shall be a valved connection that will allow insertion of 1/4" OD sampling probe extending to the center of the stack.	Customer	1	YORK	Combustion gas analyzer	YORK
Flow	Evaporator flow meter	The flow meters shall be of the type required to comply with ARI Standards. Refer to Appendix A in the York field Performance Test Procedure for further guidance on selection of flow measurement devices. Design and calibration data shall be made available to YTG to allow input to YTG's Field Data Acquisition System. These devices shall be installed with unobstructed straight run piping with a minimum of 15 pipe diameters upstream of the flowmeter and 5 pipe diameters downstream of the flowmeter. The upstream length can be shortened to 10 pipe diameters with the use of a flow straightening bundle. Pipe diameters is defined as the diameter of the flow meter and the pipe in which the flow is to be measured. Both shall be the same diameter.	Customer	1 per loop	Customer	To be determined by the customer	Customer

YPC GAS INSTRUMENTATION INSTALLATION REQUIREMENTS							
TYPE OF MEASUREMENT	DESCRIPTION	INSTALLATION REQUIREMENTS	INSTALLATION RESPONSIBILITY	NUMBER OF MEASUREMENT POINTS	INSTRUMENT SUPPLIER	INSTRUMENT TYPE	CALIBRATION RESPONSIBILITY
Flow	Condenser flow meter	The flow meters shall be of the type required to comply with ARI Standards. Refer to Appendix A in the York field Performance Test Procedure for further guidance on selection flow measurement devices. Design and calibration data shall be made available to YTG to allow input to YTG's Field Data Acquisition System. These devices shall be installed with unobstructed straight run piping with a minimum of 15 pipe diameters upstream of the flowmeter and 5 pipe diameters downstream of the flowmeter. The upstream length can be shortened to 10 pipe diameters with the use of a flow straightening bundle. Pipe diameters is defined as the diameter of the flow meter and the pipe in which the flow is to be measured. Both shall be the same diameter.	Customer	1 per loop	Customer	To be determined by the customer	Customer
Flow	Natural Gas Flowmeter	The customer shall be responsible for providing ARI/ASHRAE compliant natural gas or oil flowmeters. Design and calibration data shall be made available to YTG to allow input to YTG's Field Data Acquisition System.	Customer	1 per loop	Customer	To be determined by the customer	Customer

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