2016 Annual Conference

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Seminar 10 Performance Monitoring and Systems Testing Per ASHRAE Standards 184, 30 and the 41 Series

Chiller Performance Data Collection, Results Processing and Uncertainty

St. Louis, Missouri

Learning Objectives

Describe the 10 basic measurement parameters that are the subject of the ASHRAE 41 Series Standards Methods for Measurement Standards.

Explain how these standards can benefit test engineers in the industry and ASHRAE method of test and method of rating standard revision committees.

Apply the recent upgrades to these standards to reduce the measurement uncertainty or broaden the list of measurement methods.

Apply the methods of test to a chiller plant to monitor system efficiency.

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Acknowledgments

We would like to recognize the hard work and dedication of all of the committee members and parties that participated in any of the SPC-184 meetings leading to this point.

Outline/Agenda

- Why do we need Standard 184?
- How to apply Standard 184.
- Data point collection requirements.
- Body of data requirements.
- Data processing.

Why do we need Standard 184?

- The industry does have a standard prescribed through ASHRAE and AHRI that addresses factory chiller testing.
- The industry currently does not have a published standard that addresses the field performance testing of liquid chillers.
- In most cases it is not possible to apply a factory testing standard to field installations where instrument accuracies and installation locations cannot be optimized.
- Provide a guide for a better understanding of the instrument selection and installation effects of the test data and test results.

Std 184 Contents

How to Apply Standard 184

- This standard includes the following types of liquid-chilling systems.
  - Vapor compression cycle.
  - Absorption cycle.
- This standard does not include systems with a net refrigeration capacity less than 10 tonR [35 kW].
- This standard does not include a specification of standardized test conditions under which the liquid-chilling system must operate. Test conditions typically reflect the expected operating conditions and are customer specified.

Test Preparation

- Prior to the test there shall be a pre-test meeting between the test agency and the owner to determine the test instrument measurement locations and requirements per the instrumentation requirements portion (Appendix D) of this standard. An objective of this discussion is to agree on the expected level of uncertainty that will be achievable during the test to ensure this is acceptable to all parties.
- There shall be discussion between the test agency and owner to formulate a test plan. This test plan shall include, but not be limited to the Pre-Test Checklist items in Normative Appendix F.
- Conduct the test according to the instrumentation (types and locations), conditions, time duration, and sampling methodology agreed-to during the pre-test meeting.

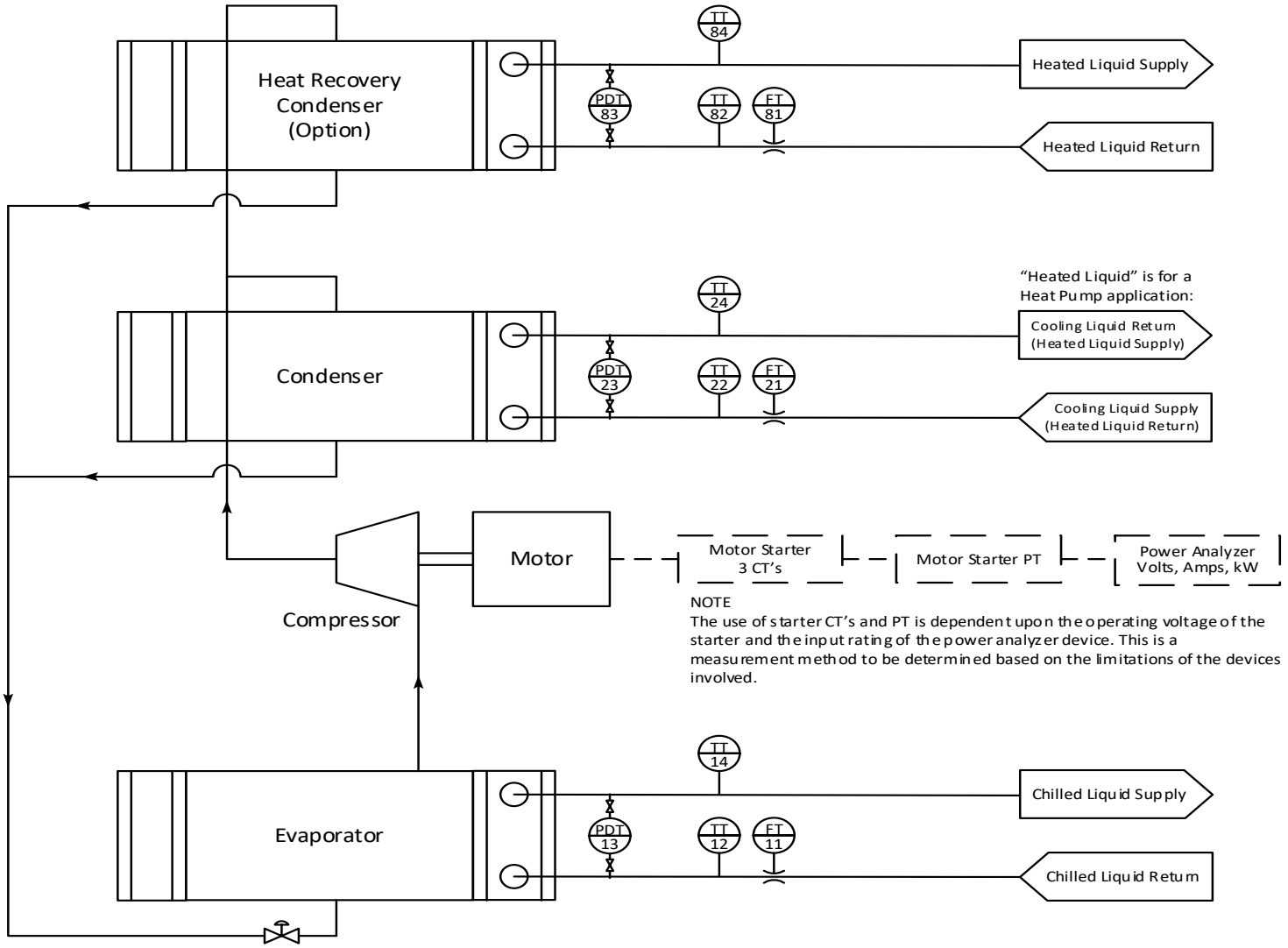
INFORMATIVE APPENDIX D INSTRUMENTATION

This informative Appendix provides reference documents related to specific kinds of test equipment. Additionally, for general overview a basic table “Overview of Instrumentation Types and Accuracy Considerations” is provided. Informative Appendix D is not intended to mandate accuracies of test equipment, however provides a guide to appropriate reference documents that cover specific kinds of test equipment

Data point collection requirements

- An example will be presented assuming an electrically driven water cooled condenser chiller or heat recovery package

Data point collection requirements



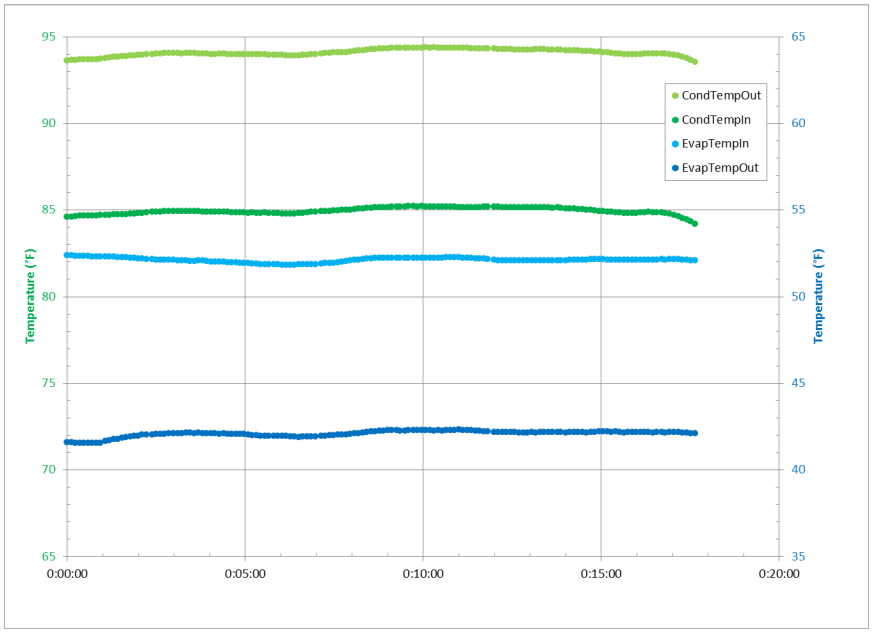
Data point collection requirements

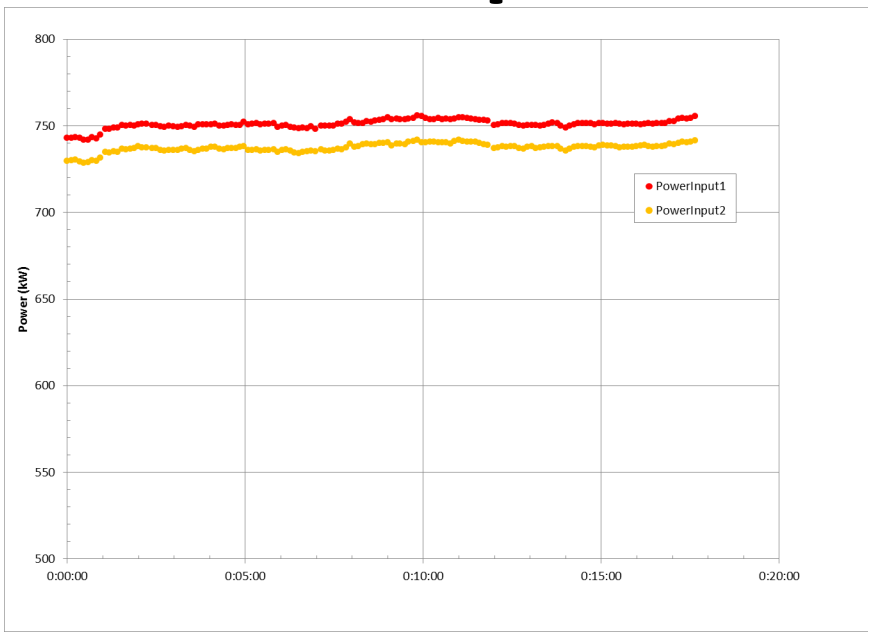
ID	Description of Measurement
FT-11	Evaporator liquid flow
TT-12	Evaporator inlet temperature
PDT-13	Evaporator pressure difference
TT-14	Evaporator outlet temperature
FT-21	Condenser liquid flow
TT-22	Condenser inlet temperature
PDT-23	Condenser pressure difference
TT-24	Condenser outlet temperature
FT-81	Heat recovery condenser (when included) liquid flow
TT-82	Heat recovery condenser (when included) inlet temperature
PDT-83	Heat recovery condenser (when included) difference
TT-84	Heat recovery condenser (when included) outlet temperature
Not identified	Power consumption for the Chiller, including any auxiliary systems included in the test boundary and includes voltage balance measurement.

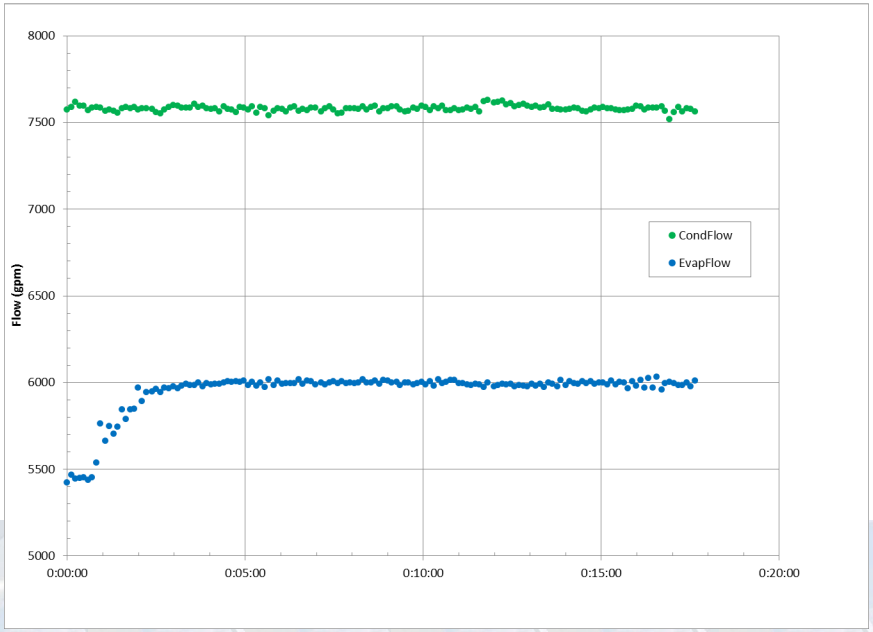
Test Data Tolerance

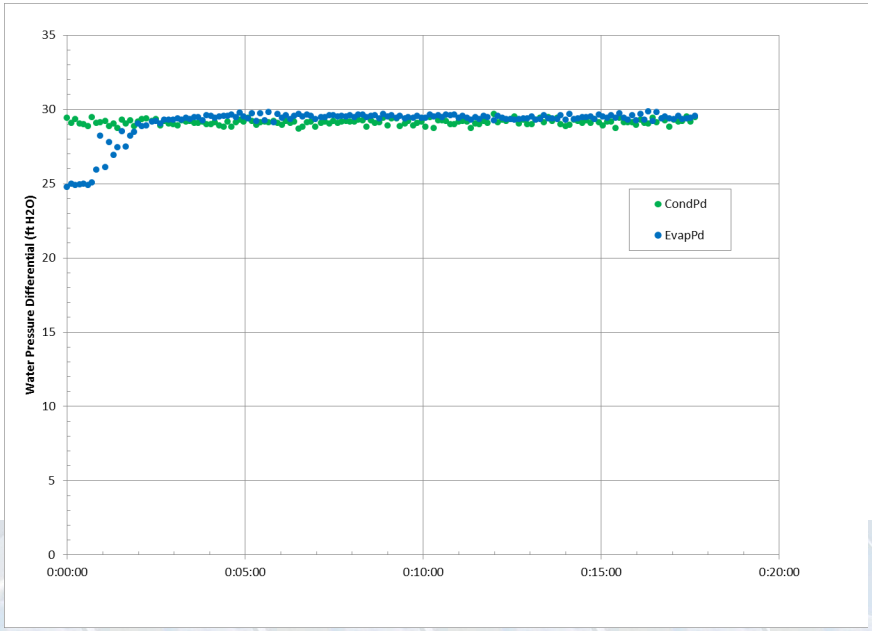
- A pass/fail tolerance is not defined as part of this standard. There are far too many field measurement variables to allow a definition to be defined as it would be for controlled measurement situations.
- Instead, Std 184 provides an uncertainty calculator tool to provide the users with two uncertainty values.
- The Pre Test Estimate (target uncertainty) which was agreed to during the pre test meeting of the parties involved.
- Post Test Results (actual uncertainty). This is calculated based on the test data and the system and stability variables associated with any field performance test.

Post test results with 150 data points





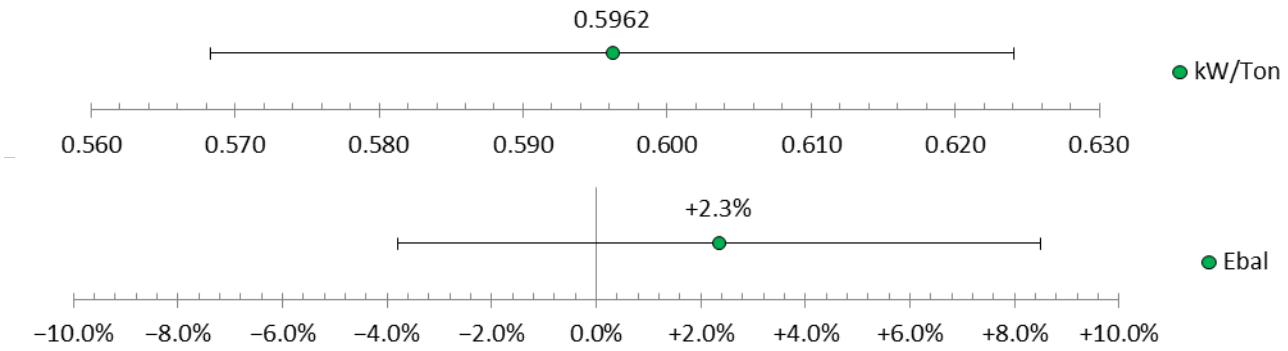




Post test results with 150 data points

Summary of Results

	Units of Measure	Average Test Value	Uncertainty Value	Relative Uncertainty
Evaporator Net Capacity	TonR	2496	±112	±4.5%
Condenser Net Capacity	TonR	2873	±127	±4.4%
Chiller Total Input Power	kW	1488	±14.0	±0.9%
Cooling Energy Efficiency	kW/Ton	0.5962	±0.0279	±4.7%
Heating Energy Efficiency	COP	6.788	±0.312	±4.6%
Evaporator Gross Capacity	TonR	2505	±112	±4.5%
Condenser Gross Capacity	TonR	2861	±127	±4.5%
Refrigerant Work Input	kW	1488	±14	±0.9%
Energy Balance	%	+2.3%	±6.2%	

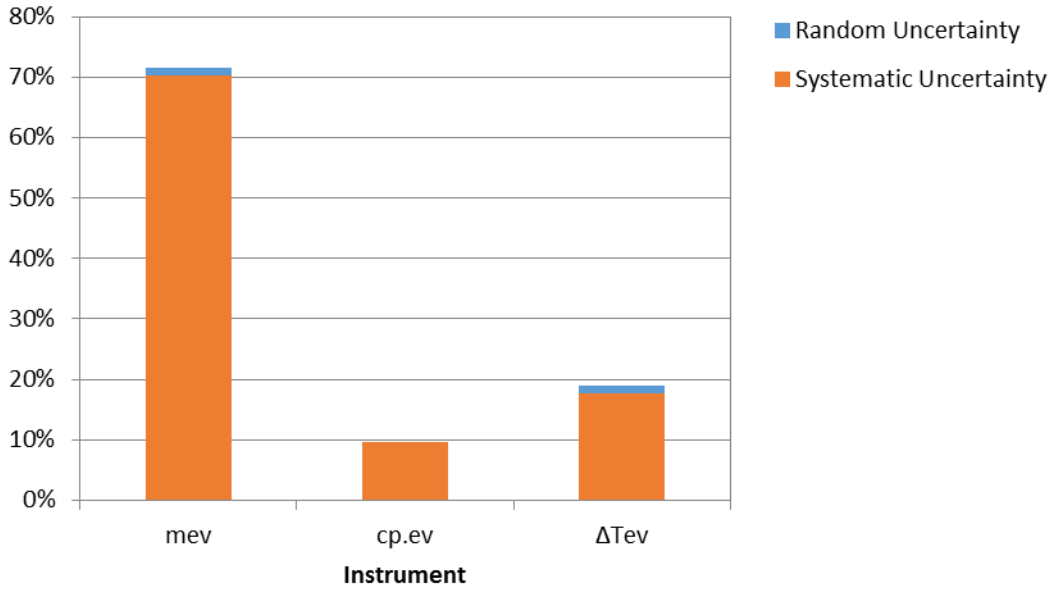


Post test results with 150 data points

Available test diagnostics:

For this particular example test setup and test data set, the chart shows the relative contributions to uncertainty of the Evaporator Net Capacity.

- Approximately 70% from mass flow, 20% from temperature difference, and 10% from specific heat.
- The systematic uncertainties (calibration, installation effects) dominate the random uncertainties (test conditions & measurements were relatively stable).



Conclusions

- Field performance testing is not an endeavor that can be categorically defined like factory chiller testing in a controlled environment.
- Due diligence from all parties prior to the test needs to occur to improve or reduce the uncertainty of the final results.
- High speed data acquisition systems with high accuracy, optimized installation of test instruments will greatly improve the final results.

Bibliography

- SPC 184, Method of Test for Field Performance of Liquid Chilling Systems

Questions?

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