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

ASHRAE Standard 30

St. Louis, Missouri

Learning Objectives

1. Describe the 10 basic measurement parameters that are the subject of the ASHRAE 41 Series Standard Methods for Measurement standards
2. Explain how these standards can benefit test engineers in industry and ASHRAE method-of-test and method-of-rating standard revision committees.
3. Apply recent upgrades to these standards to reduce the measurement uncertainty or broaden the list of measurement methods.
4. Apply the methods of test to a chiller plant to monitor system efficiency.

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Acknowledgments

- Thanks for all the work by the members of SPC 30

Outline/Agenda

- Background
- Overview of the standard
- New methods for chiller testing
- Instrumentation Requirements

Background

- ANSI/ASHRAE Standard 30-1995

  “Method of Testing Liquid-Chilling Packages”
- Superseded the 1978 edition
- Anticipated a new international standard. Development of ISO PWD 19298 was active until about 2007, but it was never published.

Background

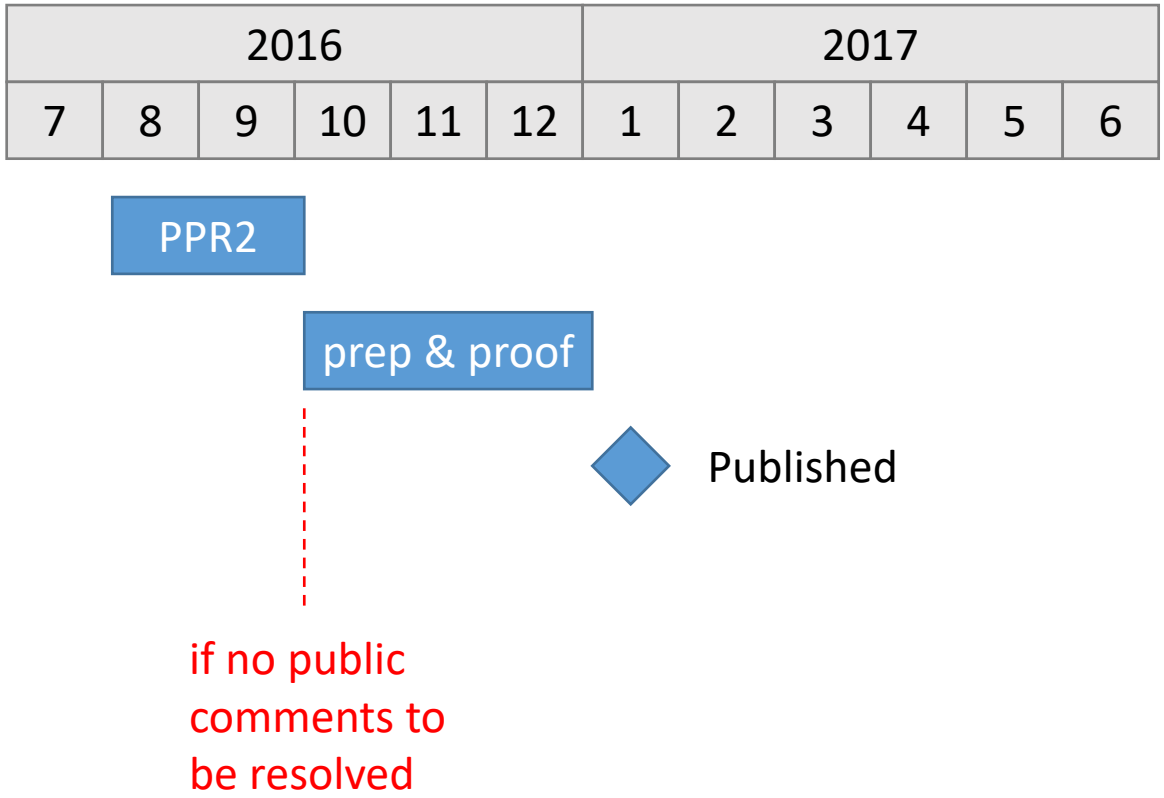
- June 2010 revision project committee authorized. Committee formed by early 2011.
- June 2011 forum held in Montreal to request input for changes.
- October 2015 publication public review.
  - Comments received. Revisions in progress. PPR2 expected Fall 2016.

Background

- Lacking an update to Standard 30 since 1995, improvements to chiller methods of testing were incorporated into Appendix C of AHRI Standard 550/590-IP (and also 551/591-SI), first in the 2011 edition and again in the 2015 edition
- AHRI will remove MOT items from those standards after ASHRAE Standard 30 is published

Background

- Tentative publication schedule



Overview

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Overview

- Purpose is to measure the thermal capacity, energy efficiency, and water pressure drop of vapor compression chillers, for both cooling and heating modes.
- Includes air-cooled, evaporatively-cooled, and liquid-cooled condenser types.

Overview

- What it is NOT:
  - Does not include testing of chillers in field installations (see ASHRAE 184P)
  - Does not specify performance tolerances (pass/fail judgment)
  - Does not specify method of rating chillers
  - Does not specify performance certification procedures
  - Not including other similar equipment types:
    - Drinking water coolers (see ASHRAE 18)
    - Unitary water-to-air heat pumps (see ASHRAE 37)
    - Absorption chillers (see ASHRAE 182)

New Methods

- Capacity defined as both gross & net
- Larger measurement sample size
- Statistical stability criteria
- Test Validity
- Measurement uncertainty
- Air temperature & water-side ΔP
- Significant digits

New Methods

- Capacity definition considers the impact of water-side frictional losses
  - Gross capacity is total energy transferred and used for energy balance calculation
  - Net capacity is the useful energy transferred and available for cooling or heating the load

New Methods

Larger measurement sample size

1995 Edition

- 3 sets of data
- t=0,5,10 minutes

New Edition

- Minimum 30 data point measurements
- Minimum 15 minutes

New Methods

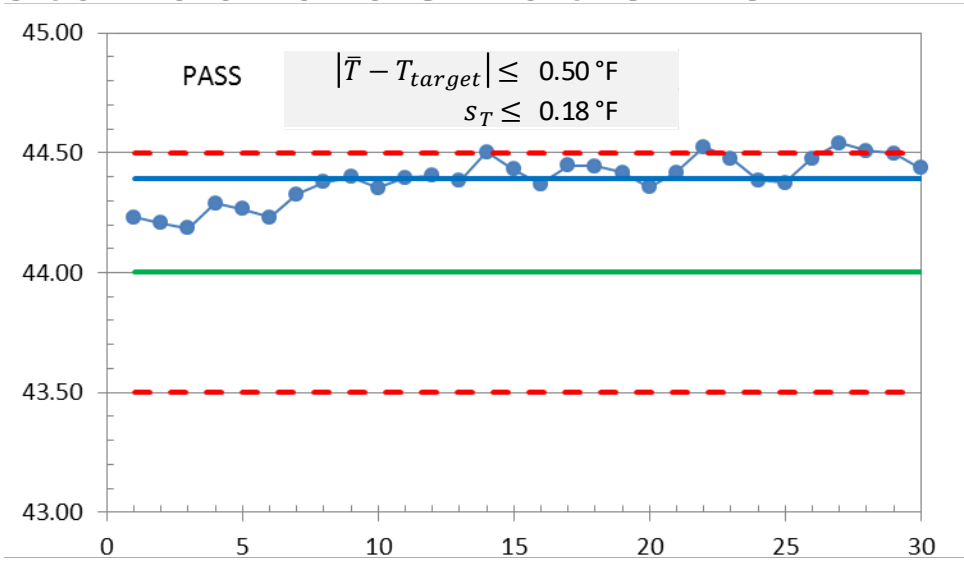
- Stability criteria use standard deviation of measured values

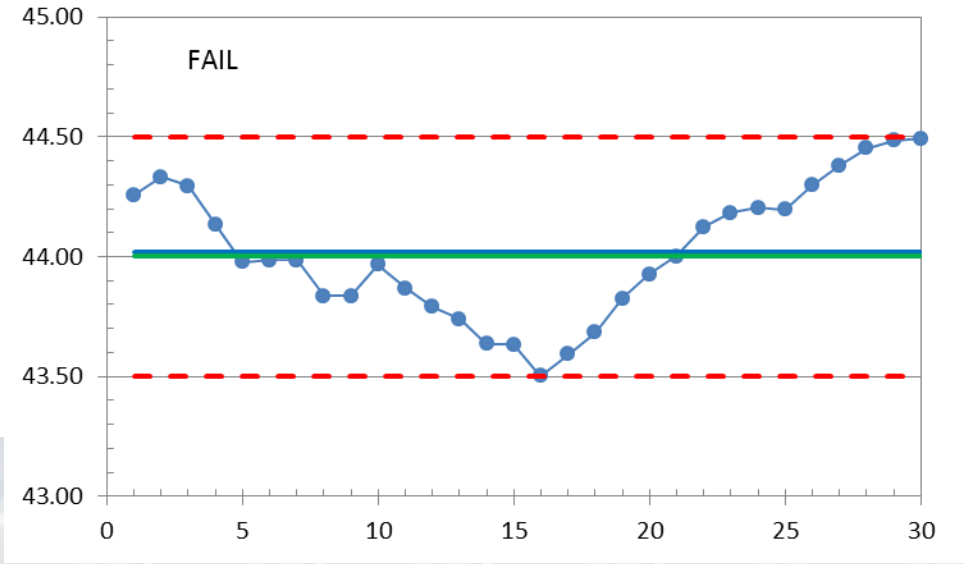
sample mean

$$\bar{x} = \frac{1}{n}\sum_{j=1}^{n}(x_j)$$

sample standard deviation

$$s = \sqrt{\frac{1}{n-1}\sum_{j=1}^{n}(x_j - \bar{x})^2}$$





New Methods

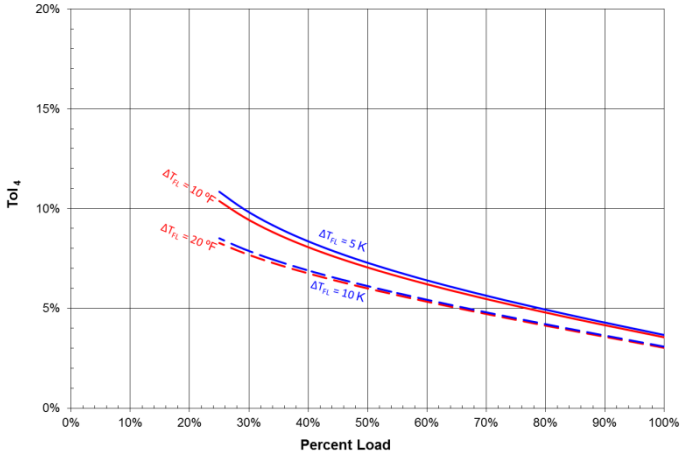
Test Validity

1995 Edition

- Heat balance (using net capacity)

New Edition

- Energy balance (using gross capacity, tolerance reduced by 25%)



- Voltage balance ≤ 2%

New Methods

- Measurement & result uncertainties calculated in accordance with ASME PTC 19.1-2013 “Test Uncertainty”

Gross Capacity

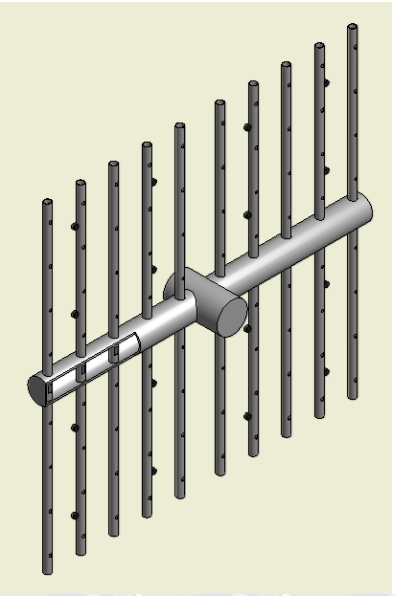
$$Q' = mc_p\Delta T + m\frac{\Delta p}{\rho} \qquad Q' \pm U_{Q',95} \text{ (at confidence interval of C=95\%)}$$

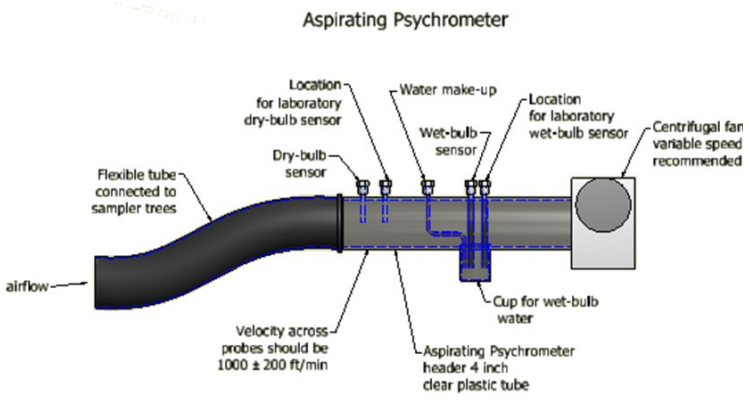
$$U_{Q'} = \sqrt{(\theta_m U_m)^2 + \left(\theta_{c_p} U_{c_p}\right)^2 + (\theta_{\Delta T} U_{\Delta T})^2 + \left(\theta_{\Delta p} U_{\Delta p}\right)^2 + \left(\theta_\rho U_\rho\right)^2}$$

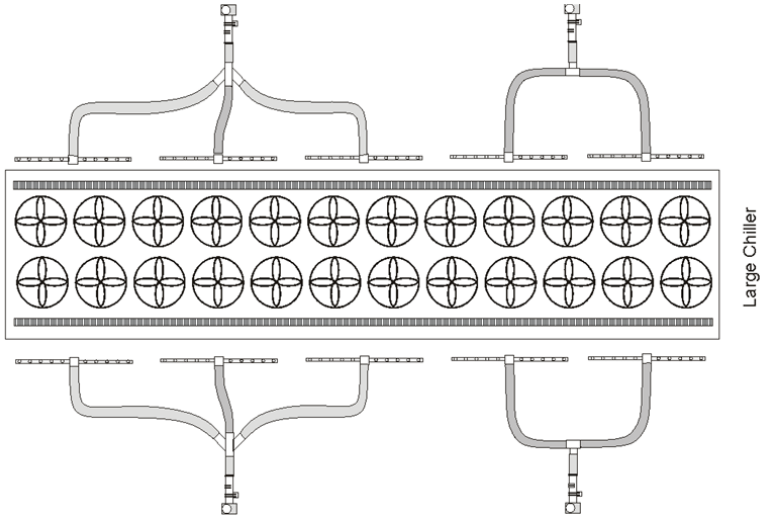
$$\bar{X}_i \pm U_{\bar{X}_i} \qquad \theta_i = \frac{\partial Q'}{\partial \bar{X}_i} \qquad U_{\bar{X}} = t_C \cdot u_{\bar{X}} \qquad u_{\bar{X}} = \sqrt{(b_{\bar{X}})^2 + (s_{\bar{X}})^2}$$

New Methods

- Air-cooled chiller entering air temperature now requires use of air sampling tree(s) and aspirating psychrometer(s)

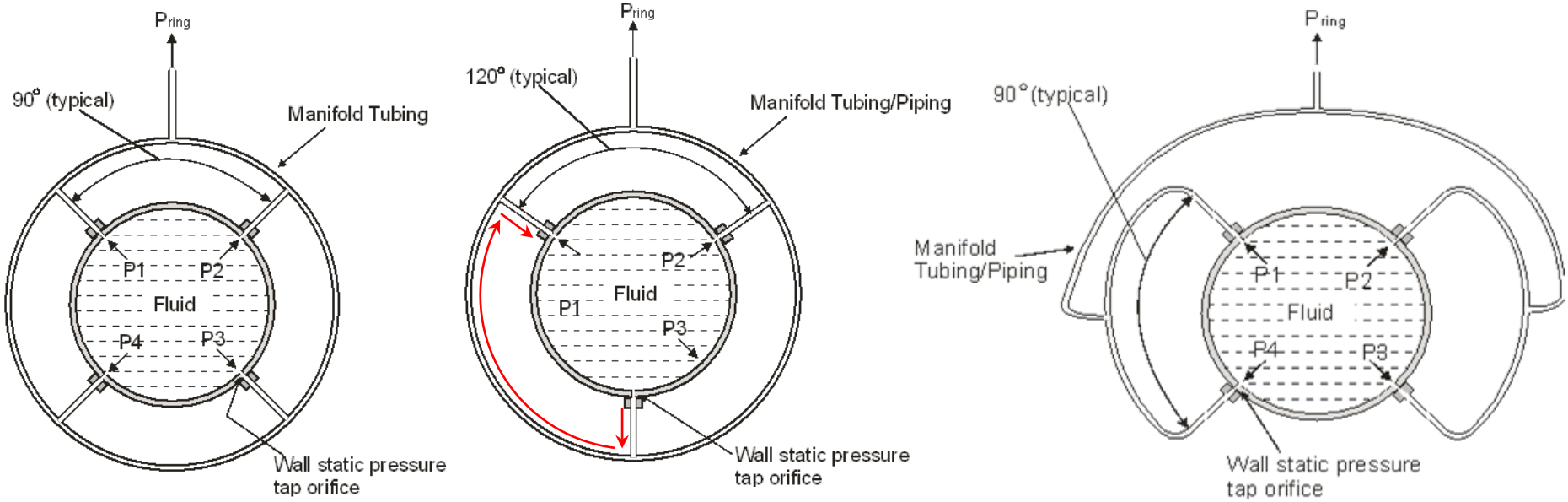






New Methods

- Liquid pressure differential now required to use piezometer rings. In many cases an additional measurement pipe section and calculated Δp adjustment.



New Methods

- Significant digits
  - Uncertainty values reported with two significant digits
  - Reported test results are rounded to same level of significance as the least significant digit of the uncertainty

10.573593 ± 0.097369424

⇩

± 0.097

⇩

10.574 ± 0.097

Instrumentation

possible changes in PPR2

Table 6.4 Requirements for Test Instrumentation

Measurement	Measurement System Accuracy[2,3,4,5]	Display Resolution[6, 7]	Selected, Installed, Operated, Maintained in Accordance With
Liquid Temperature	±0.11°C (±0.20°F)	0.005°C (0.01°F)	ANSI/ASHRAE Standard 41.1
Air Temperature	±0.11°C (±0.20°F)	0.05°C (0.1°F)	ANSI/ASHRAE Standard 41.1
Liquid Mass Flow Rate [1]	±1.0% RDG	4 significant figures	ASME Power Test Code PTC 19.5 (flow measurement) ASME MFC-16 (electromagnetic type) ASME MFC-3M (orifice & venturi type) ASME MFC-6M (vortex type) ASME MFC-11 (coriolis type) ISA Standard RP31.1 (turbine type)
Differential Pressure	±1.0% RDG	3 significant figures	ASME Power Test Code PTC 19.2
Electrical Power ≤ 600V > 600 V	±1.0% FS, ±2.0% RDG ±1.5% FS, ±2.5% RDG	4 significant figures (V, A, kW, Hz)	IEEE 120 IEEE C57.13 (R2003)
Atmospheric Pressure	±1.0 kPa (±0.15 psia)	0.1 kPa (0.01 psia)	ASME Power Test Code PTC 19.2
Steam condensate mass flow rate	±1.0% RDG	4 significant figures	
Steam pressure	±1.0% RDG	3 significant figures	
Fuel volumetric flow rate	±1.0% RDG	4 significant figures	
Fuel energy content	-	3 significant figures	Gas quality shall be acquired by contacting the local authority and requesting a gas quality report for calorific value on the day of the test

+ ASHRAE Standard 41.6

⇨ ASHRAE Standard 41.8

⇨ ASHRAE Standard 41.3

⇨ ASHRAE Standard 41.11

⇨ ASHRAE Standard 41.3

Bibliography

- ASHRAE 2015. BSR/ASHRAE Standard 30P, Public Review Draft, “Method of Testing Liquid-Chilling Packages”, October 2015.

Questions?

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