WHPA Work Product Summary

DATE: January 14, 2015

INITIATING BODY: WHPA CQM Standard 180 Maintenance Task Working Group

WORK PRODUCT NAME: CQM Committee ANSI/ASHRAE/ACCA Standard 180 Maintenance Task Working Group Report – Refrigeration Cycle Performance - System Performance Analysis

TYPE OF ACTION REQUESTED: ☒ **VOTE** ☐ **GUIDANCE** ☐**OTHER**: The Initiating Body requests that the referenced Work Product as approved by the WHPA Commercial Quality Maintenance Committee (CQM) be adopted by the WHPA Executive Committee (EC) as a WHPA work product and also subsequently released to the ANSI/ASHRAE/ACCA Standard 180 Committee.

APPROVAL HISTORY

WORKING GROUP: WHPA CQM Standard 180 Maintenance Task Working Group

☒ **BY CONSENSUS** ☒ **BY VOTE (email supplement)**

TALLY: There was a unanimous aye vote with no opposed or abstained. The voting members present were BNB Consulting, CLEAResult, FDSI, Honeywell ECC, and SCE. There was also a supplemental email vote to ensure overall quorum consensus. The email vote also yielded a unanimous aye vote with no opposed or abstained from the following voting members: NCI, MAS Service, ACCA, HVACRedu.net, CSG, ASHRAE, Marina Mechanical.

DATE: October 30, 2014 (consensus vote), November 13, 2014 (supplemental email vote completion)

COMMITTEE: WHPA Commercial Quality Maintenance Committee

☐ **BY CONSENSUS** ☒ **BY VOTE**

TALLY: There was an email vote conducted with votes confirmed at the December 9 committee meeting. The vote results were eight aye, zero nay and five abstentions. No vote was obtained from Integrity Mechanical Systems Corp. The motion to approve and elevate the working group report to the Executive Committee passed. Aye votes were cast by ACCA, Aire Rite AC & Refrigeration, ASHRAE, FDSI, Honeywell ECC, Marina Mechanical, SCE and Western Allied Corp. Abstention votes were cast by CSG, Honeywell Smart Grid Solutions, CLEAResult (PECI), PG&E and Tre' Laine Associates.

DATE: December 9, 2014

WORK PRODUCT OBJECTIVES: The CQM Committee appointed the Maintenance Task Working Group to complete a detailed review of refrigeration cycle performance for the purpose of informing the California Utility Programs and users of ANSI/ASHRAE/ACCA Standard 180. The Working Group established the following four objectives for this report:

1. To determine the meaning of acceptable refrigeration cycle performance
   a. To try to find a way to bring the airflow centered view and the refrigeration cycle view of equipment performance together with simple and realistic tasks in the field.
2. To determine how to detect unacceptable performance in a maintenance context.
3. To determine the maintenance tasks required to produce or maintain acceptable performance.
4. To document any other pieces of information that the work group feels is informative about this subject.

CA ENERGY EFFICIENCY PLAN STRATEGIC GOAL ALIGNMENT:

☐ GOAL 1 ☒ GOAL 2 ☐ GOAL 3 ☐ GOAL 4

CEESP HVAC GOAL STRATEGIES: Strategic Plan Goal 2: Quality HVAC installation and maintenance becomes the norm. The marketplace understands and values the performance benefits of quality installation and maintenance.

• Strategy 2.1: Create a statewide quality installation and maintenance (QI/QM) brand that will be attached to systems/installation/contactors that meet quality standards.

BENEFITS: The detailed analyses completed by the Working Group's technical experts from diverse backgrounds should improve overall effectiveness in performing Standard 180 system performance analysis tasks related to refrigeration cycle performance as part of a fixed priced maintenance agreement and ultimately result in improved energy efficiency savings based on the cumulative effect of the recommendations. The findings' recommendations also propose updates that may influence subsequent versions of Standard 180 for enhanced accuracy and improved understanding acknowledging that any changes proposed are made with the knowledge that the Standard represents the minimum acceptable maintenance practice, even if some of the detail of the report may highlight best practices. Key benefits are expected from the following report conclusions:

1. Thermodynamic analysis requires several sequential steps. Each step has information requirements that may or may not get met. Without information, in practice, you have to estimate or guess. Those estimations or guesses combine and degrade the precision or accuracy of the final diagnostic outcome.
2. The primary information challenge, in practice, is knowing the goal values and the acceptable range of values for the refrigeration cycle performance indicators for a unit under the current operating conditions.
3. The current common approach is to have a simple rule-of-thumb for each performance indicator. That has been shown to not be effective enough.
   a. Proprietary technologies exist that model the system operation based on the design and the driving conditions but this working group believes that referring to them is currently outside this project's scope.
4. The working group recommends a different approach to determining these goal values that if implemented, would help the technician as raw data and also give analysis technology more information that would produce better precision and diagnostic accuracy. That approach requires collecting and preserving commissioning data in a way that is always accessible to the servicing personnel. The working group recommends a physical embodiment of the commissioning or initial performance data, such as a sticker to be installed on the inside panel to protect it from weather.

• For what is the first time in the working group's collective experience, there was a collaboration between people with the airflow centered approach to system analysis and those with a refrigeration cycle centered approach that produced a suggestion that could, again, for the first time in the working group's experience, bring airflow analysis into the very competitively priced commercial maintenance process.

WHPA Work Product Summary

OUTSTANDING ISSUES / DEBATES / MINORITY VIEWS: Despite its best efforts in this second attempt at evaluating it, the Working Group was still unable to determine goal values to fully analyze the refrigeration cycle performance objectives. Tables were included on pages 11-12 of the report clarifying the reason and the suggestion that “some technology solution” would be needed to address the issue.

NOTE: The bottom 3 rows in Figures 1b and 1c were corrected from reading “Air Flow” to “ΔTe” following email comments received after the CQM Committee meeting.

POTENTIAL AUDIENCE: WHPA CQM Committee, WHPA Executive Committee, WHPA Council of Advisors, ANSI/ASHRAE/ACCA Standard 180 Committee, Contractors, Technicians, IOUs, CEC, and CPUC.

MOTION to the Executive Committee: That the ‘Commercial Quality Maintenance Committee ANSI/ASHRAE/ACCA Standard 180 Maintenance Task Working Group Report Table 5-22 Rooftop Units Refrigeration Cycle Performance ***System Performance Analysis’*** dated January 14th, 2015, be adopted as an official WHPA Report.

VOTE TALLY: On January 14th, 2015, the following 11 EC member organizations or their designated proxies voted as follows to adopt the presented report and the above detailed motion: aye votes from ACCA, AHRI, ASHRAE, CPUC, HARDI, IHACI, JCEEP, NCI, PG&E, SDG&E, UA; no abstentions; CEC, SCE and SCG were not present.

FURTHER ACTIONS REQUIRED: WHPA Staff will ensure the required motion steps are completed for finalization and posting of the report, plus the drafted letter of appreciation.

NEXT STEPS: It is strongly encouraged that the detailed report be reviewed to ensure understanding of the full impact of the detailed analysis of the refrigeration cycle performance objectives for both the air side and refrigeration side system performance analyses and their related integration, as well as a visual representation of the proposed inside panel data tag (sticker) for commissioning or initial performance data, and the definitions the Working Group used for initial performance, baseline condition documentation, commissioning, maintenance, and fully loaded operation.

EC Co-Chair Bob Baker will provide the approved work product to the Standard 180 revision committee for their consideration, review and discussion at their committee meeting convening on Friday January 23, 2015.

Western HVAC Performance Alliance

Commercial Quality Maintenance Committee
ANSI/ASHRAE/ACCA Standard 180
Maintenance Task Working Group Report Table 5-22
Rooftop Units
Refrigeration Cycle Performance
System Performance Analysis

A WHPA Report dated January 14, 2015

Prepared on behalf of the Maintenance Task Working Group
By Dale T. Rossi
Field Diagnostics Services, Inc.

Table of Contents

Introduction

Technical experts from diverse backgrounds worked together and reached a consensus on the following four items:

- Thermodynamic analysis requires several sequential steps. Each step has information requirements that may or may not get met. Without information, in practice, you have to estimate or guess. Those estimations or guesses combine and degrade the precision or accuracy of the final diagnostic outcome.

- The primary information challenge, in practice, is knowing the goal values and the acceptable range of values for the refrigeration cycle performance indicators for a unit under the current operating conditions.

    - The current common approach is to have a simple rule-of-thumb for each performance indicator. That has been shown to not be effective enough.

    - Proprietary technologies exist that model the system operation based on the design and the driving conditions but this working group believes that referring to them is currently outside this project's scope.

- The working group recommends a different approach to determining these goal values that if implemented, would help the technician as raw data and also give analysis technology more information that would produce better precision and diagnostic accuracy. That approach requires collecting and preserving commissioning data in a way that is always accessible to the servicing personnel. The working group recommends a physical embodiment, a sticker like the one shown in figure 3.

- For what is the first time in the working group's collective experience, there was a collaboration between people with the airflow centered approach to system analysis and those with a refrigeration cycle centered approach that produced a suggestion that could, again, for the first time in this work group's experience, bring airflow analysis into the very competitively priced commercial maintenance process.

Background

The Commercial Quality Maintenance Committee of the Western HVAC Performance Alliance appointed a Maintenance Task Working Group to complete a detailed study of refrigeration cycle performance for the purpose of informing the CA utility programs and users of the ANSI/ASHRAE/ACCA Standard 180.

Objectives

1. To determine the meaning of acceptable refrigeration cycle performance
    a. To try to find a way to bring the airflow centered view and the refrigeration cycle view of equipment performance together with simple and realistic tasks in the field.
2. To determine how to detect unacceptable performance in a maintenance context.
3. To determine the maintenance tasks required to produce or maintain acceptable performance.
4. To document any other pieces of information that the work group feels is informative about this subject.

Approach

1. The Commercial Quality Maintenance Committee established a Working Group.
2. Dale Rossi served as lead for the Working Group.
3. Members of the Working Group are volunteers from members of the full Committee (See Exhibit A).

Definitions

Initial performance – The process of adjusting and documenting the performance of the equipment as left after the initial contract maintenance inspection. The Initial performance captures the same data captured by the commissioning document for use in the maintenance process, but there is no assumption that the equipment performance is acceptable as compared to some known standard.

Baselining – The working group determined for our purposes, baselining has the same definition as commissioning.

Commissioning (retro-commissioning, re-commissioning) – The process of adjusting and documenting the performance of the equipment to closely match the known system design performance or the known manufacturers performance specifications.

Maintenance – A periodic inspect, test, document and notify process

Fully loaded operation – 1) Operating constant volume equipment with all compressors running 2) Operating variable volume equipment to perform as a fully loaded constant volume equipment.

Assumptions

1. All diagnostic tests assume fully loaded operation
2. All refrigeration cycle diagnostics tests assume steady state operation or 15 minutes of runtime prior to testing.
    a. Condenser fans must be running at full speed
3. All refrigeration cycle tests specified assume standard package units and split systems. These tests are not applicable to VRF/VRV systems or ductless split systems.
4. All refrigeration cycle diagnostics tests assume cooling only equipment or a heat pumps operating in the cooling mode.
5. All refrigeration cycle diagnostics tests must be performed above a minimum ambient temperature
6. All refrigeration cycle diagnostics tests must be performed above a minimum return air wet bulb temperature
7. All diagnostics tests assume the economizer is at min. pos. or closed.
8. When no performance data is known, assume there is no high static fan accessory.
9. All air-side diagnostics tests are generally performed with a wet coil.
    a. Manufacturers' often also provide dry coil airflow tests for use in dry climates.
10. All air-side test assume new filters

Findings

1. Maintenance is defined as “A periodic inspect, test, document and notify process” The concepts discussed are intended to support a quick and easy way to detect significant performance degradations on a maintenance inspection or by processing the data collected on a maintenance inspection. This is distinct from servicing equipment to achieve good performance. Servicing procedures are outside the scope of this document.

2. Any proposals made by this Working group recommending changes to the standard are made understanding that the standard represents the minimum acceptable maintenance practice. The Working group may highlight best practices in the details of the report, but that is distinct from recommended modifications to the standard.

3. Proposals to the Standard 180 committee for modifications to the standard.

    a. The working group proposes that a standard set of performance data be defined for use in evaluating the performance of a specific unit as compared to how it performed at 1) commissioning (assumed acceptable performance) or 2) Initial performance (not assumed acceptable performance).

    b. The Working group proposes that each unit when taken under maintenance have a commissioning document or that an initial performance document shall be produced.

        i. Ideally, this document is produced at equipment commissioning. It could be produced at a re-commissioning or retro-commissioning.

        ii. When no commissioning data is available, the working group recommends that the initial performance be documented.

        iii. This proposal specifically does not indicate that commissioning or retro-commissioning is a requirement for equipment maintainability.

    c. The working group proposes that the data in the performance document be designated as commissioning data or initial observed performance data

    d. The working group proposes that one potential embodiment for a performance document could be a sticker placed in a convenient location in or on the equipment where it is protected from the weather.

    e. The working group recognizes that the performance data may be preserved using a technology solution, however because the equipment may be maintained by different organizations over time, a sticker that is permanently attached to the equipment with the data is a good way to assure the performance data is available to the maintainer over the service life of the equipment.

    f. The working group has determined that the position of the outside air intake damper is an important variable that must be controlled to evaluate the air flow and the refrigeration cycle performance. The working group suggests that measuring the outside air intake opening with a ruler is a way that the minimum position could be checked during maintenance. The working group suggests that marking the place where the measurement was taken with a permanent marker is required for this measurement to be reproducible.

g. The working group determined that measuring and documenting the return air and supply air static pressures where the access ports exist could be done today with the tools and expertise available to the average technician and the comparison of the current TESP with the documented TESP will very quickly give an objective indication as to if the airflow through the unit has changed from the documented airflow.

h. The working group proposes the following data set as a commissioning or initial performance document requirement.

   i. Equipment design data
      1. Unit name
      2. Make
      3. Model
      4. Serial number
      5. Manufacture Year
      6. EER
      7. Refrigerant type
      8. Metering device type
      9. If TxV, the SC goal
      10. Total system charge (lbs., oz.s)
      11. Nameplate TESP
   ii. Additional design data from commissioning
      1. Design CFM , CFM/ton
      2. Design TESP
      3. Fan RPM
      4. Outside air intake damper opening
      5. Design minimum outside airflow
      6. Signal to the actuator (vdc or milliamps)
      7. Measured TESP
   iii. Electrical power data
      1. Voltage
      2. Whole unit current
      3. Indoor fan current
      4. Condenser fan current 1-n
      5. Compressor current 1-n
      6. Power factor
      7. If VFD, fully loaded Hz
   iv. Air-side data
      1. Return static
      2. Supply static
      3. RAWB
      4. RADB
      5. SAWB
      6. SADB
   v. Refrigeration cycle data
      1. SP
      2. ST
      3. LP
      4. LT
      5. AMB
      6. Air off the condenser

i. Maintenance process suggestion - The evaluation of the equipment's performance at the time of maintenance could be a comparison between the current measured performance and the documented performance of that equipment at the time of the initial performance evaluation or commissioning.

j. The working group determined that there are several different acceptable approaches to maintenance based on the user's performance objectives and condition indicators. The previous data set proposal is intended to be comprehensive. Some maintenance plans may not use all the data available and some data may not always be collected when making the commissioning/ initial performance document.

k. The working group determined that defining goal values for the refrigeration cycle performance indicators is challenging and not available using current field methods. The assumption is that a system for establishing goal values will become available. That problem is difficult enough to be outside the scope of this report. See the section called Goal values for refrigeration cycle performance indicators and Figure 2 for more information.

l. Charge diagnostics is not equipment performance analysis.

Fault detection concepts

Air-side diagnostics

The working group determined that air-side performance measurement is useful as a maintenance concept.

Common air-side faults and degradations

1. Insufficient air flow
2. Excessive air flow

Information required for detecting faults:

1. Return static pressure
2. Supply static pressure

Performance indicators

1. Total external static pressure

Establishing the Airflow Performance Objective
Note: values provided are rules of thumb only and are not universally applicable

Rule of thumb guidance for packaged rooftop units						
Equipment design or commissioning data values known						
	Units	Perf. Target		Goal value	Low Fault Threshold	High Fault Threshold
Air Flow						
Air flow	Total ESP (in. W.C.)	Design or commissioned CFM value	-	Design or commissioned TESP value	Design or commissioned * 0.8	Design or commissioned * 1.2
Air flow	CFM	Design or commissioned CFM value	-	Design or commissioned CFM value	-	-
Air flow	CFM/ton	Design or commissioned CFM/ton value	-	Design or commissioned CFM/ton value	Design or commissioned – 50CFM/ton	Design or commissioned + 50CFM/ton
Return static	(in. W.C.)	Design or commissioned static value	-	Design or commissioned static value	Design or commissioned * 0.8	Design or commissioned * 1.2
Supply static	(in. W.C.)	Design or commissioned static value	-	Design or commissioned static value	Design or commissioned * 0.8	Design or commissioned * 1.2
Return/supply imbalance	ratio	Design or commissioned balance	-	Design or commissioned balance	Design or commissioned * 0.8	Design or commissioned * 1.2
Electrical						
Fan current	Amps	Design or commissioned current value	-	Design or commissioned value	Design or commissioned * 0.8	FLA *s.f.
Voltage	Voltage	Unit specific				
Fan watts	Watts					
Fan RPM	RPM	Design or commissioned RPM value	-	Design or commissioned value	Design or commissioned * 0.8	Design or commissioned * 1.2
The values below are compared to an absolute standard, not commissioning values.						
ΔTe	°F	>60WB	Humid	-	8	24
ΔTe	°F	40-60WB	Moderate	-	12	28
ΔTe	°F	<40WB	Dry	-	16	32

Figure 1a

Rated Equipment Performance known (not commissioning data)						
	Units	Perf. Target		Goal value	Low Fault Threshold	High Fault Threshold
Air Flow						
Air flow	Total ESP (in. W.C.)	300-400 CFM	Humid	Rated ESP	Rated * 0.4	Rated * 1.6
Air flow	Total ESP (in. W.C.)	350-450 CFM	Moderate	Rated ESP	Rated * 0.4	Rated * 1.4
Air flow	Total ESP (in. W.C.)	400-500 CFM	Dry	Rated ESP	Rated * 0.4	Rated * 1.2
Return static	(in. W.C.)	Useful for trending				
Supply static	(in. W.C.)	Useful for trending				
Return/supply imbalance	ratio	Useful for trending				
Electrical						
Fan current	Amps	80+% of FLA (pf)	-	FLA * 0.8	FLA * 0.5	FLA * 1.1
Voltage	Voltage	Unit specific				
Fan watts	Watts					
The values below are compared to an absolute standard, not commissioning values.						
ΔTe	°F	-	-	-	8	32
ΔTe	°F	>60WB	Humid	-	8	24
ΔTe	°F		Moderate	-	12	28
ΔTe	°F	<40WB	Dry	-	16	32

Figure 1b

Rated performance unknown		Perf. Target		Goal value	Low Fault Threshold	High Fault Threshold
Air Flow						
Air flow	Total ESP (in. W.C.)	350-450 CFM	Up to 20 ton	0.8	0.2	1.2
Air flow	Total ESP (in. W.C.)	-	Above 20 ton	Rule of thumb not recommended, additional effort should be taken to find fan performance data		
Return static	(in. W.C.)	Useful for trending				
Supply static	(in. W.C.)	Useful for trending				
Return/supply imbalance	ratio	Useful for trending				
Electrical						
Fan current	Amps	80+% of FLA (pf)	-	FLA * 0.8	FLA * 0.5	FLA * 1.1
Voltage	Voltage	Unit specific				
Fan watts	Watts					
The values below are compared to an absolute standard, not commissioning values.						
ΔTe	°F	-	-	-	8	32
ΔTe	°F	>60WB	Humid	-	8	24
ΔTe	°F		Moderate	-	12	28
ΔTe	°F	<40WB	Dry	-	16	32

Figure 1c

Refrigeration cycle faults and degradations

Common refrigeration cycle faults

1. Insufficient low side heat transfer
2. Excessive low side heat transfer
3. Insufficient high side heat transfer
4. Excessive high side heat transfer
5. Insufficient refrigerant charge mass
6. Excessive refrigerant charge mass
7. Insufficient refrigerant mass flow
8. Excessive refrigerant mass flow
9. Inefficient compressor
10. Contaminants in the refrigerant

Information required for detecting faults:

1. Suction pressure
2. Liquid (or discharge) pressure
3. Suction temperature
4. Liquid temperature
5. Ambient temperature
6. Return air wet bulb temperature

Performance indicators

1. Evaporating temperature
2. Superheat
3. Condensing temperature over ambient
4. Subcooling

Goal values for refrigeration cycle performance indicators.

The point of the tables below is to show that a particular unit under 105°F amb and 74°F RAdb can have an evaporating temperature goal value that changes 10°F to 13°F with the variation in RAwb from 50°F-70°F. If you assign a range 5°F of acceptable values around the goals it means the acceptable evaporator temperature ranges from 33°F to 56°F for a 13 SEER FO unit over that range of normal humidity values with all other conditions remaining constant. This range of acceptable values is not useful for performance analysis. The point of this discussion is to show that any simple rule of thumb cannot produce an acceptable outcome most of the time. It seems clear that some technology solution for determining goal values is required to competently analyze the refrigeration cycle performance.

Modeled unfaulted fixed orifice equipment performance.

10 SEER - Fixed Orifice

SEER	Ref	metering	OA	Rawb	ET	SH	COA	SC
10	22	FO	65	50	36	10	23	NA
10	22	FO	65	60	39	19	26	NA
10	22	FO	65	70	42	33	28	NA
10	22	FO	105	50	42	0	22	NA
10	22	FO	105	60	45	0	24	NA
10	22	FO	105	70	52	13	28	NA

13 SEER - Fixed Orifice

SEER	Ref	metering	OA	Rawb	ET	SH	COA	SC
13	22	FO	65	50	33	12	13	NA
13	22	FO	65	60	37	19	14	NA
13	22	FO	65	70	42	33	15	NA
13	22	FO	105	50	38	0	15	NA
13	22	FO	105	60	41	0	15	NA
13	22	FO	105	70	51	13	17	NA

All tables assume 74°F RA

Figure 2a

Modeled unfaulted TxV equipment performance

10 SEER - TXV

SEER	Ref	metering	OA	Rawb	ET	SH	COA	SC
10	22	TxV	65	50	33	20	16	10
10	22	TxV	65	60	39	20	20	10
10	22	TxV	65	70	47	20	24	10
10	22	TxV	105	50	40	20	19	10
10	22	TxV	105	60	43	20	21	10
10	22	TxV	105	70	52	20	25	10

13 SEER - TXV

SEER	Ref	metering	OA	Rawb	ET	SH	COA	SC
13	22	TxV	65	50	35	20	15	10
13	22	TxV	65	60	40	20	16	10
13	22	TxV	65	70	49	20	18	10
13	22	TxV	105	50	41	20	17	10
13	22	TxV	105	60	44	20	17	10
13	22	TxV	105	70	53	20	20	10

All tables assume 74°F RA

Figure 2b

Data Tag

The following graphic, Figure 3, is an example of what a commissioning or initial performance data tag my look like when reduced to practice. It would be installed on an inside panel to protect it from the weather.

Pressure ports

In order to have reproducible airside data, holes must have been drilled to make the pressure and temperature measurements. If no holes are found, the airside data cannot be considered reproducible. The commissioning process should include a requirement that pressure ports be added so that entering and leaving static pressure can be measured and recorded.

The data presented in the record was measured and recorded under the following conditions:

Commissioning or re-commissioning (assumed to be correct)	
Post tune-up (not assumed to be correct)	
Initial inspection (not assumed to be correct)	

Equipment design data

Unit Name	
Make	
Model	
Serial number	
Manufacture Year	
EER	
Metering device type	

	1	2	3	4
If TxV, the SC goal				
Refrigerant type				

Split system only

	1	2	3	4
Total system charge				

Nameplate TESP	

Additional design data from commissioning

Air flow data

Design CFM , CFM/ton	
Design TESP	
Fan RPM	

Economizer data

Outside air intake damper opening(in inches at marked location)	
Design minimum outside airflow (CFM)	

Electrical power measured data

	L1-L2	L1-L3	L2-L3
Voltage			

	L1	L2	L3
Whole unit current			
Indoor fan current			
Power factor			

	L1	**L2**	**L3**
Condenser fan current 1			
Condenser fan current 2			
Condenser fan current 3			
Condenser fan current 4			

	L1	**L2**	**L3**
Compressor current 1			
Compressor current 2			
Compressor current 3			
Compressor current 4			

Air-side measured data

If VFD, fully loaded Hz	
Return static	
Supply static	
TESP	
RAWB	
RADB	
SAWB	
SADB	

Refrigeration cycle measured data

System	**1**	**2**	**3**	**4**
SP				
ST				
LP				
LT				
AMB				
Air off the condenser				

Example of a system performance data tag design

Figure 3

Conclusion

Technical experts from diverse backgrounds worked together and reached a consensus on the following four items:

- Thermodynamic analysis requires several sequential steps. Each step has information requirements that may or may not get met. Without information, in practice, you have to estimate or guess. Those estimations or guesses combine and degrade the precision or accuracy of the final diagnostic outcome.

- The primary information challenge, in practice, is knowing the goal values and the acceptable range of values for the refrigeration cycle performance indicators for a unit under the current operating conditions.

    - The current common approach is to have a simple rule-of-thumb for each performance indicator. That has been shown to not be effective enough.

    - Proprietary technologies exist that model the system operation based on the design and the driving conditions but this working group believes that referring to them is currently outside this project's scope.

- The working group recommends a different approach to determining these goal values that if implemented, would help the technician as raw data and also give analysis technology more information that would produce better precision and diagnostic accuracy. That approach requires collecting and preserving commissioning data in a way that is always accessible to the servicing personnel. The working group recommends a physical embodiment, a sticker like the one shown in figure 3.

- For what is the first time in the working group's collective experience, there was a collaboration between people with the airflow centered approach to system analysis and those with a refrigeration cycle centered approach that produced a suggestion that could, again, for the first time in the working group's experience, bring airflow analysis into the very competitively priced commercial maintenance process.

Appendices

Appendix 1 - Glossary

AOC, (Air off the condenser) – The temperature of the air leaving the condenser coil or more typically leaving the condenser fans; it is compared to the ambient temperature or the temperature of the air entering an air cooled condenser.

AMB, (Ambient air temperature) - Air within a defined space. Air surrounding a building, the source of outdoor air brought into a building, etc.

CFM, (Cubic feet per minute) - The volumetric rate of flow of air

COA, (Condensing temperature over ambient) – A calculation comparing the condensing temperature to the ambient temperature; it is useful in evaluating the high-side pressure in a refrigeration system.

Condensing temperature - (1) the saturation temperature, in °F (°C), corresponding to the refrigerant pressure at the condenser heat exchanger outlet. (2) The saturation temperature, in °F (°C), corresponding to the measured refrigerant pressure at the condenser outlet.

Condensing temperature over ambient goal – The modeled COA no-fault expectation

Current - Movement or flow of charge in an electrical circuit, measured in amperes.

Dry bulb - The dry-bulb temperature (DB) is the temperature of air measured by a thermometer freely exposed to the air but shielded from radiation and moisture. DB is the temperature that is usually thought of as air temperature and it is the true thermodynamic temperature.

EER, (energy efficiency ratio) - (1) ratio of net cooling capacity in Btu/h to total rate of electric input in watts under designated operating conditions.

ET, (Evaporator temperature) - Temperature at which a fluid vaporizes at a given pressure

Evaporator temperature goal – The modeled ET no-fault expectation

FO, (Fixed orifice) – A type of metering device used in a refrigeration system where the orifice size is fixed.

kW, (kilowatt) - The kilowatt is equal to one thousand (10^3) watt. The watt (symbol: W) is a derived unit of power in the International System of Units (SI), named after the Scottish engineer James Watt (1736–1819). The unit is defined as joule per second and can be used to express the rate of energy conversion or transfer with respect to time.

kWh, (kilowatt hour) - Is a unit of energy equal to 1,000 watt-hours, or 3.6 mega joules.

LP, (Liquid pressure) - The measured liquid pressure in a refrigeration system

LT, (Liquid temperature) - The temperature of the liquid line in a refrigeration system

PF, (Power factor) **-** A factor, equal to the cosine of the phase angle between current and voltage, by which the product of voltage and current is multiplied to convert volt amperes to power in watts.

RADB, (Return air dry bulb) –The dry bulb (air temperature not taking humidity into account) temperature of the air in the return air duct before it enters the rooftop unit.

RAWB, (Return air wet bulb) –The wet bulb (air temperature taking humidity content in air into account) temperature of the air in the return air duct before it enters the rooftop unit.

Return static, (Return air static pressure) -Static pressure measured in the return air duct before it enters the rooftop unit. Static pressure is the force exerted on the duct not due to the velocity pressure from the moving air.

RPM, (Revolutions per minute) **-** Is a measure of the frequency of a rotation. It annotates the number of turns completed in one minute around a fixed axis. It is used as a measure of rotational speed of a mechanical component.

RTU, (Rooftop unit) **-** A HVAC unit on the roof of a building consisting of a blower, heating and cooling elements, filter racks or chamber, dampers, humidifier, and other central equipment in direct contact with the airflow. This does not include the ductwork through the building.

SADB, (Supply air dry bulb) **-** The dry bulb (air temperature not taking humidity into account) temperature of the air in the supply air duct as it leaves the rooftop unit.

SAWB, (Supply air wet bulb) **-** The wet bulb (air temperature taking humidity content in air into account) temperature of the air in the supply air duct as it leaves the rooftop unit.

SC, (Subcooling) **-** process of cooling refrigerant below condensing temperature for a given pressure.

SEER, The SEER rating of a unit is the cooling output during a typical cooling-season divided by the total electric energy input during the same period. The higher the unit's SEER rating the more energy efficient it is.

SH, (Superheat) **-** The heat added to a gas after it has completely vaporized, resulting in a temperature rise

SP, (Suction pressure) – The measured low-side pressure in a refrigeration system

ST, (Suction temperature) – The temperature of the suction line in a refrigeration system

Subcooling goal - The modeled SC no-fault expectation

Superheat goal **-** The modeled SH no-fault expectation

Supply static, (Supply air static pressure) -Static pressure measured in the supply air duct after it leaves the rooftop unit. Static pressure is the force exerted on the duct not due to the velocity pressure from the moving air.

TESP, (Total external static pressure) – TESP is the static pressure external to a fan bearing device. TESP is used to evaluate the air flow through a RTU or air handler. Higher TESP readings indicate that fan energy is being used to move air through high resistance to air flow in the supply or return duct. Higher TESP means lower airflow through the system.

TxV, (Thermostatic expansion valve) - A type of metering device used in a refrigeration system where the orifice size is variable. It is used to maintain a superheat specification.

VFD, (Variable frequency drive) - electronic device that varies its output frequency to vary the rotating speed of a motor, given a fixed input frequency. Used with fans or pumps to vary the flow in the system as a function of a maintained pressure.

Voltage - Electric potential or potential difference expressed in volts.

VRF/VRV, (Variable refrigerant flow/variable refrigerant volume) – A HVAC system type that is outside the scope of this document

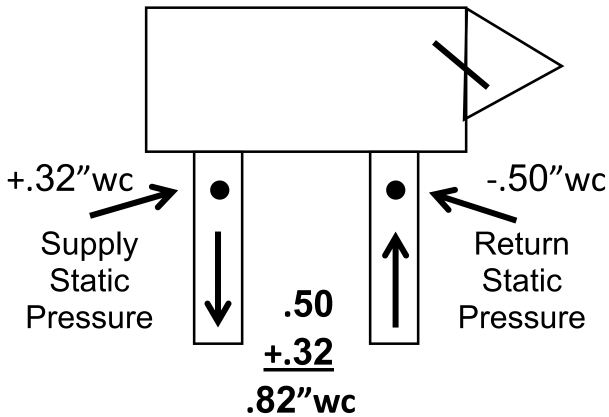
Wet bulb -The wet-bulb temperature is the lowest temperature that can be reached under current ambient conditions by the evaporation of water only; it is the temperature felt when the skin is wet and exposed to moving air. Wet-bulb temperature is largely determined by both actual air temperature (dry-bulb temperature) and the amount of moisture in the air (humidity).

ΔT, (Delta T) – The change in the dry-bulb temperature of air before and after passing through a heat exchanger in a HVAC system

Appendix 2 –Measuring Total External Static Pressure (TESP)

Total External Static Pressure (TESP) is the static pressure external to a fan bearing device. The tools used to measure TESP include a manometer, connective flexible tubing, static pressure tip, a Pitot tube or other appropriate device.

The return and supply static pressures are measured and recorded. The return is under negative pressure and the supply has positive pressure. The absolute value of the return and supply static pressures are summed to provide the Total External Static Pressure. Duel port manometers can be used to display TESP readings directly.



* Test port locations are for demonstration purposes only.

When measuring TESP in a maintenance context, it is important that the outside air damper is in the same position as it was when the reference TESP was measured.

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