Summary

This document provides specific recommendations for a standardized field data specification to be collected for system measurements to be collected for commercial HVAC installations. This specification is a first step toward the development of a standardized approach for establishing field performance measurement protocols to score the level of performance achieved by an installed HVAC system.

Finalized: December 13, 2016

Use of this document

This document provides specific recommendations for a standardized field data specification for system measurements to be collected for commercial HVAC installation.

It is based on an official WHPA Work Product of December 9, 2016, titled "Standardized Field Data Specification for Commercial HVAC Installation". This Work Product was developed by the WHPA Commercial Quality Installation Committee.

This document, and also the WHPA Work Product, may be used in part or whole at no charge. Attribution to the Western HVAC Performance Alliance is requested.

We would also ask that you inform the WHPA through info@performancealiance.org if you have made use of either document, so that we can inform and encourage the hundreds of volunteers who donate their time to providing expert HVAC advice in order to support energy efficiency objectives.

Recommendations for Standardized Field Data Specification for Commercial HVAC installation

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BACKGROUND

The WHPA Executive Committee has authorized the formation of a working group tasked with developing a standardized field data specification for HVAC installation and maintenance programs. This specification will be used to define and standardize field data collected by program contractors, tracked by program implementers and used by program evaluators.

Field measurements formalized under this specification are intended to be used for program accomplishment progress and tracking, program impact evaluation, and customer savings calculations.

The specification is an important first step toward the development of a standardized approach for establishing field performance measurement protocols to score the level of performance achieved by an installed HVAC system. This is only the first phase of the specification. Additional phases include the development of required formulae, calculations and specific test protocols. The data referred to in this phase of the specification development is described below.

A working group was formed, chaired by Peter Jacobs of BuildingMetrics, Boulder, Colorado, and staffed by volunteers representing contractors, manufacturers, trade organizations, consultants, utilities, program administrators and educators. This Cross-Committee Working Group represents and support the efforts of four WHPA committees ─ Residential Installation (RI), Commercial Installation (CI), Commercial Maintenance (CM), and Energy Savings & DEER.

PROJECT APPROACH AND SCOPE

This specification is a work product of the Standardized Field Data Specification Working Group. The scope of this specification is limited to data necessary to score the performance of an installed HVAC system and is initially intended to support activities related to Commercial Installation. It also includes data that should be collected during system installation that will be necessary to support subsequent maintenance activities.

Collaboration by the working group initially resulted in several subsets of data necessary to support Commercial Installation, Commercial Maintenance, and Residential Installation activities. The creation of the subsets of data ultimately led to the decision to create three versions of the specification. The first version supports Commercial Installation. Subsequent versions will address Commercial Maintenance and Residential Installation.

This initial specification is intended for unitary, single zone systems only. Additional data fields may be added in the future, as necessary to support Goal 4 and Goal 5 above.

Following the achievement of all three goals for the Commercial Installation version of the specification, the working group will create versions for Commercial Maintenance and Residential Installation. Each version will then be reviewed and approved by the corresponding WHPA committee. The final versions will then each be presented to the WHPA Executive Committee for acceptance and adoption as WHPA approved work products.

This work product will be freely shared in collaboration with the ASHRAE SPC 221 committee - *A Test Method to Measure and Score the Operating Performance of an Installed Constant Volume Unitary HVAC System.* The intent is to create an HVAC industry standard that will establish a field performance scoring protocol that can be voluntarily implemented within the HVAC industry.

OBJECTIVES

The outcome of this specification is a performance score measured on the airside of an installed HVAC system accurately representing the field measured efficiency of the entire system, including the unitary equipment and associated distribution system.

System scoring is based on the following metrics:

- Field measured total capacity at the equipment
- Field measured sensible capacity at the equipment
- Field measured EER at the equipment
- Field Measured distribution system efficiency
- Field measured system delivered capacity
- Field measured system delivered EER
- Benchmark Performance Indicators that may be used during maintenance to identify changes in system performance once an initial system score has been established.

This specification is a component of a test and calculation method that can be used to score the performance of commercial HVAC systems by contractors, field technicians, verifiers, EM&V professionals, utilities, regulators and program administrators. It addresses a subset of the requirements of several related industry standards and is designed to be compliant with the relevant sub-sections of each related standard, including:

- ACCA Standard 5
- IPMV International Performance Measurement and Verification protocol
- ASHRAE Guideline 0 the Commissioning Process
- ASHRAE Guideline 14 Measurement of Energy and Demand Savings.
- AGC AABC Commissioning Group Standards
- NEBB CXPP Building Commissioning Process Standards
- APPA Standard 1000 Total Cost of Ownership for facilities
- SMACNA Duct Construction Standards

EFFICIENT INSTALLATION DEFINED

A 2016 goal of the Commercial Installation Committee was creating a definition of an efficient installation that is dependent on the effectiveness of the scoring method described in this specification. The scoring method produces a ratio of the system delivered Btu/hr. to the rated capacity of the equipment. This score is a number easily identifiable by consumers, technicians, contractors, utilities and regulators to quantify the installed performance of a system.

Efficient Installation Definition – An efficient commercial or residential installation is defined as an HVAC system having the delivered system capacity and efficiency, field measured into the conditioned occupied space, that meets or exceeds a predetermined percent of equipment rated efficiency.

Efficient Commercial Installation refers both to the process of field-measuring and documenting the performance of an installed HVAC system; and to the objective of achieving improvements in measured performance.

The process of field-measuring efficiency is an emerging technology, and details of the engineering calculations and measurement protocols are the subject future work. The completed WHPA Commercial

Installation Field Data Collection Specification will define the measurement and calculation process necessary to quantify installed efficiency. As this specification is operationalized, efficiency targets may be developed that various types of installations must achieve to qualify for incentives under utility efficiency programs.

SPECIFICATION CONTENT

The content of this specification is divided into the following sections:

1. General Job Data
2. Utility Information
3. General System Information
4. In-Field Test Data
5. Required Test Instruments
6. Questions and Answers

GENERAL JOB DATA

- This general job data need only be collected on the initial visit to the system
- Data can be reviewed at each technician visit and it must be able to be updated at any time
- The company office staff may enter or update any of this data as well.

Data Point Number	Data Point Name	Data Point Description
CONTRACTOR AND TECH INFORMATION		
1.1	Contractor company name	Company name
1.2	Contractor Address	Street, PO, City, State, Zip
1.3	Contractor Phone	Office phone number
1.4	Tech name	First and Last
CUSTOMER INFORMATION		
1.5	Customer/company name	Company name or building owner or owner's representative
1.6	Customer Address	Street, PO, City, State. Zip
1.7	Customer Phone	Home or office Number
1.8	Contact name	First and Last
1.9	Contact Phone	Personal phone number
1.10	Contact email	Email for contact person
JOB INFORMATION		
1.11	Site name	Name of this location

Data Point Number	Data Point Name	Data Point Description
1.12	Site address	If other than billing address
1.13	Elevation	Local site elevation to calculate air density changes
1.14	Unique Identifier	Unique ID for site, unit, and test. This identifier is used to associate the test data with the job number, utility incentive application number, or other related data.

UTILITY INFORMATION

- This data is specified by the program manager and may be adapted to suit each individual program.
- Information in this table is not required for testing and scoring of systems outside of utility programs.
- Cyber security policies must be adhered to when handling sensitive information.

Data Point Number	Data Point Name	Description
2.1	Building Type	Specific building types as defined by program
2.2	Climate Zone	Climate zone where the building is located
2.3	Electric Meter Number	Meter number service the system tested
2.4	Electric Account Number	Billing account number
2.5	Gas Meter Number	Meter number service the system tested
2.6	Gas Meter Account Number	Billing account number
2.7	Measures installed	Measure names and/or measure codes
2.8	Incentive application number if known	Contractor incentive application number to Utility or Program Implementer
2.9	Building Vintage	Specific building vintage categories (date ranges) as defined by the program
2.10	HVAC System Vintage	Specific HVAC vintage (date range) categories associated with the most recent renovation of the HVAC system tested. Enter if different from Building Vintage
2.11	Data entry date	Data entry date
2.12	Technician certification	Type and certification number(s) for all related or required certifications

GENERAL SYSTEM INFORMATION

- Data found in this tab describes each individual HVAC system.
- The data in this tab will only need to be collected one time. Thereafter it may be updated as equipment components are replaced or other changes are made in the system.

Data Point Number	Data Point Name	Data Point Description
SYSTEM DESCRIPTION		
3.1	System name	System name or number
3.2	Area service	Descriptive name of area served
3.3	Equipment location	Physical location of equipment
3.4	Duct system location	Area the duct system is installed
3.5	Square feet served	Floor square feet served by system
EQUIPMENT DATA		
3.6	Outdoor unit manufacturer	Outdoor unit make
3.7	Outdoor unit model number	Outdoor unit model number - all digits
3.8	Outdoor unit Tons	interpret tons from model number
3.9	Outdoor unit serial number	Outdoor unit serial number
3.10	Indoor unit manufacturer	Indoor unit make
3.11	Indoor unit model number	Indoor unit model number - all digits
3.12	Indoor unit serial number	Indoor unit serial number
3.13	Gas heating input	For gas fired equipment only
3.14	Gas heating output	For gas fired equipment only
3.15	Unit or system identifier	RTU-1. AC-3, etc.
3.16	Year manufactured	Year of equipment manufacture
3.17	Identification sticker number	System current program sticker number
3.18	EER	Cooling efficiency
3.19	Fan Type	Direct Drive, Variable Speed, VFD, Pulleys/Belt
3.20	Fan rated pressure	Total External Static Pressure
3.21	Fan motor horsepower	Blower motor rated horsepower
ECONOMIZER DATA		
3.22	Economizer make	Economizer manufacturer
3.23	Economizer model	Economizer model number

Data Point Number	Data Point Name	Data Point Description
3.24	Economizer type	Temperature, enthalpy, single v. differential, DCV (demand control ventilation) option, etc.
3.25	Controller type	Analog or ADEC (Advanced Digital Economizer Controller)
3.26	Controller Make	Economizer controller manufacturer
3.27	Controller Model	Economizer controller model number (NA if integrated with unit)
3.28	Exhaust type	Barometric or power exhaust
3.29	Economizer changeover Setpoint(s)	Controller changeover settings
CONTROLS		
3.30	Tstat make	Thermostat or EMS make
3.31	Tstat model	Thermostat or EMS model number
3.32	Tstat Type	Manual/Non-Programmable, Programmable, EMS/BMS (energy management/building management system)
3.33	Cooling stages	Number of cooling stages controlled by thermostat
3.34	Heating stages	Number of heating stages controlled by thermostat
3.38	Control system type	Name or general description
3.35	Thermostat settings (temps and hours of operation)	Schedule and settings for thermostat
3.36	Fan settings (on/auto, hours of operation)	Schedule and settings for supply fan
DESIGN CRITERIA		
3.37	Design economizer changeover set point(s)	Controller changeover setting
3.39	Design Cfm	System design supply flow rate (Cfm)
3.40	Design Total External Static Pressure	System design total external static pressure
3.41	Design min Outside Air	System design minimum outdoor air (Cfm)
3.42	Design total supply airflow	Total of supply register design airflow
3.43	Design total return airflow	Total of return grille design airflow

IN-FIELD TEST DATA

- Testing is intended to be conducted with all cooling stages fully operational and the economizer operating at minimum fresh air setting. Unless otherwise noted
- These are the minimum data points required to quantify the operating efficiency and capacity of the system before and after improvements are made.
- The same data points and testing are completed before and after the improvements are made to the system to document the improvements made in the capacity and efficiency of the system

TEST PARAMETERS		
4.1	Test type	Pre-System Improvement Performance Score, Post System Improvement Performance Score, Initial System Assessment, maintenance benchmarking.
4.2	Test in/test out	Do data represent test in or test out performance
4.3	Date of test	Day/Month/Year
4.4	Time of day	Time of day when data are recorded
4.5	Ambient temperature during temperature testing	Outdoor dry bulb temperature during test at the location of the outdoor equipment, near the condenser inlet.
THERMOSTAT		
4.6	Were all stages of heating or cooling calling during the testing?	Yes or No
4.7	Was the testing in heating or cooling mode?	Identify equipment mode during test (heating or cooling)
AIRSIDE PRESSURES		
4.8	Equipment entering pressure	Return duct pressure, a component of the Total External Static Pressure (TESP) calculation. Used to assess the distribution system; and to benchmark and track airflow changes.
4.9	Equipment exiting pressure	Supply duct pressure, a component of the TESP calculation. Used to assess the distribution system; and to benchmark and track airflow changes.
4.10	Measured Fan Total Pressure (if specified on nameplate)	Use only when fan total pressure is used for estimating airflow
4.11	Supply fan airflow	Measured supply fan airflow (cfm) at full cooling
4.12	Airflow test method	Test method used – velocity traverse, manufacturer fan data tables (based on fan rpm and static pressure rise), TrueFlow plates, etc.
4.13	Fan RPM or Motor Speed Setting	Use only when fan total pressure is used for estimating airflow. Fan speed (RPM), dip switch, speed tap, or

		VFD (Hz)
4.14	Supply register individual airflow	Use a commercial air balance hood or a duct traverse per ASHRAE 111
4.15	Total supply register airflow	Total of all supply registers
4.16	Return grille individual airflow	Use a commercial air balance hood or a duct traverse per ASHRAE 111
4.17	Total return grille airflow	Total of all return registers
ECONOMIZER		
4.18	Ventilation (economizer) airflow Test method	Test method used - velocity traverse, enthalpy balance, etc.
4.19	Ventilation (economizer) minimum airflow cfm	Measured by airflow traverse, velocity grid, or estimated from mixed air, return air and outdoor air enthalpy balance and total air flow
4.20	Economizer changeover setpoint	Temperature or enthalpy setting
4.21	Economizer maximum airflow cfm	Measured by airflow traverse or velocity grid, or estimated from mixed air, return air and outdoor air enthalpy balance and total air flow. Enter same as minimum if economizer non-functional.
4.22	Signal to outdoor air damper actuator at minimum position, or % open.	Used for benchmarking minimum position. V, mV, mA etc. depending on actuator or % open when signal doesn't indicate position.
AIRSIDE TEMPERATURES (Drybulb only in heating mode)		
4.23	Equipment return duct entering WB	Return duct wetbulb temperature near unit connection
4.24	Equipment return duct entering DB	Return duct drybulb temperature near unit connection
4.25	Equipment supply duct entering WB	Supply duct wetbulb temperature near unit connection
4.26	Equipment supply duct entering DB	Supply duct drybulb temperature near unit connection
4.27	Economizer or OSA entering WB	Wetbulb temperature at outdoor air intake
4.28	Economizer or OSA entering DB	Drybulb temperature at outdoor air intake
4.29	Mixed air temperature WB	Average entering Wetbulb temperature at cooling coil (measured when using enthalpy balance method for calculating outside air quantity; otherwise calculated)
4.30	Mixed air temperature DB	Average entering drybulb temperature at cooling coil (measured when using enthalpy balance method for calculating outside air quantity; otherwise calculated)
4.31	Average return grill air temperature WB	Wetbulb temperature averaged across appropriate return air grilles
4.32	Average return grill air temperature DB	Drybulb temperature averaged across appropriate return air grilles
4.33	Average supply register air temperature WB	Wetbulb temperature averaged across appropriate supply air grilles

4.34	Average supply register air temperature DB	Drybulb temperature averaged across appropriate supply air grilles
ELECTRICAL DATA		
4.35	Supply fan watts at full cooling and Minimum OSA setting	Total fan watts summed across all phases with economizer at minimum position
4.36	Supply fan watts at full cooling and Maximum OSA setting	Total fan watts summed across all phases with economizer at maximum position
4.37	Total Unit watts at full cooling and Minimum OSA setting	Total watts summed across all phases with unit at full cooling and economizer at minimum position

REQUIRED COMMERCIAL TEST INSTRUMENTS

This table includes instruments required to perform testing in the previous table. Minimum accuracy, resolution and ranges are listed. Continuous technology advancements are bringing a variety of test instruments to the market having the capacity to gather data remotely from multiple sources that meets or exceeds these requirements.

Test Instru-ment	Test Instrument Name	Minimum Accuracy	Minimum Resolution	Minimum Range	Calibration Period	Test Instrument Description
AIR PRESSURE MEASUREMENT (Choose one or more of the following)						
1	Digital Manometer	±3%	.01" W.C.	0-10"	12 Months	Kit Includes, pressure hoses, static pressure tips, drill bit, drill bit sheath and hole plugs
2	Magnehelic Gauge	±3%	.01" W.C.	0-10"	12 Months	
AIRFLOW MEASUREMENT						
3	Air Balancing (Capture) Hood	±3%	1 CFM	30-2000 CFM	12 Months	Commercial balancing, backpressure compensating hoods only
(Choose one or more of the following)						
4	Hotwire Anemometer	±5%	1 CFM	1-5000 FPM	12 Months	Programmable with duct/grille size. Able to calculate airflow
5	Rotating Vane Anemometer	±5%	1 CFM	1-5000 FPM	12 Months	
AIR TEMPERATURE MEASUREMENT						
6	Digital Thermometer	±2%	.1º F dry bulb	20º-180ºF	12 Months	Reliable and repeatable readings required
7	Digital Hydrometer	±2%	.1ºF wet bulb	5% to 95% RH	12 Months	No sling psychrometers permitted
POWER MEASUREMENT						

Test Instru-ment	Test Instrument Name	Minimum Accuracy	Minimum Resolution	Minimum Range	Calibration Period	Test Instrument Description
8	Electric Power meter	±2%	1Volt/ 1Amp/ .1 W	0-600 Volts 0-100 Amps	12 Months	True RMS with power factor, watts. Single and three phase voltage.
9	Remote Probe/Clamp	±2%	N/A	0-100 Amps	12 Months	Required to reach into blower compartments

QUESTIONS AND ANSWERS

How will this testing be used in the field?

This initial specification is designed for use in utility programs. The test method will typically be used to test and quantify the performance of an installed HVAC system before any improvements have been made. Additional diagnostic tests not covered under this data specification can be added to further diagnose the system and prepare a scope of work to renovate the system and improve performance. Following system upgrades, this test will be repeated and the results compared to document the field measured changes in capacity and system efficiency obtained from the renovation activity.

What events will trigger each type of testing?

This testing is being required when a system enters a utility program to quantify pre and post system performance as a program requirement.

This testing is currently being used primarily by mechanical contractors and service companies in response to customer complaints of comfort or excessive energy consumption, and is followed by a proposal for system renovation. It is often used when it is time for equipment replacement[1] and results in distribution system upgrades being added to the equipment change out scope of work.

Abbreviated versions of this test are used during routine service to bring customer awareness to poorly performing systems. Performance is invisible to consumers. Testing brings awareness of substandard performance, solutions and opportunities and motivates customers to take action.

When will this data be collected?

The *General Job Data* will be gathered on the initial visit to the job site. Or it can be pulled from existing service records, if a previous relationship exists with the service company and the customer.

Utility Information will be collected if the system enters a utility program.

General System Information may be partially found in installation and service records or may be gathered at the initial site visit. Some general system information is recorded fresh each time the performance of the system is evaluated.

In-Field Test Data will be collected by a qualified technician during live field testing on the jobsite following industry standards and sequences using calibrated test instruments.

Who will be collecting this data?

[1] System replacement may qualify as a Space-Conditioning System Alteration under Title 24, which requires a building permit and duct leakage sealing on new ducts and ducts running through unconditioned space.

General Job Data is assembled by the installation crew if the system is new or newly renovated.

Utility and General System Information can be taken by a service or maintenance tech, or by a sales consultant while surveying the project to evaluate the need for improvements equipment replacement or upgrades.

In-Field Test Data will always need to be taken by a trained technician following industry standards and best practices.

How will this data be maintained and archived?

The data will be collected by the technician and contractor support staff as indicated above, and archived by the contractor. Data may also be transferred to an efficiency program contracting entity according to the terms and conditions of the program participation contract. Software currently exists and is available on the cloud to automate this process. The software is available for use by qualified persons in the HVAC industry. This software is accessible through any device with access to the internet. Paper forms are also available. When benchmarking performance for service use, labels are placed on equipment listing benchmarked data taken when the system was commissioned to which comparisons can be made to detect changes in performance over the life of the system.

How will this data be made available and be used for subsequent technician visits?

The ability to compare test data and track any change in the performance of the system is the key strength of HVAC system performance measurement. Having ongoing access to performance data by software in the cloud is ideal. Service records can be uploaded with the data and made available for ongoing comparison. Labels are placed on equipment for ongoing reference and updated with each use. Facility managers can use software or paper files to track the performance of each system.

Quality Assurance

Effective quality assurance must be based on the collection and comparison of reliable, repeatable field data. The volume of data required to complete this test method is carefully balanced to enable effective automated reviews to confirm the accuracy of the testing, as well as repeatable field testing by a qualified contractor.

The key to accurate QA is 1) conformance with fundamental system physics informed by essential, traceable and repeatable performance measurements as well as 2) tracking their relationship to each other as the system conditions change compared to expectations based on system physics.

Evaluation, Measurement and Verification (EM&V)

The test methods and processes used to assess the performance of HVAC energy efficiency programs by contractors and EM&V professionals should be coordinated. This data specification established a basis for coordinating the data gathering and reporting functions across program implementation and evaluation.

How does this testing mesh with existing industry standards?

This test method draws from a wide variety of existing industry standards and rolls them into a single test and calculation method. These include portions of ASHRAE Standards 111; 1; 152; 41.1; 70; portions of ACCA Standard 5, as well as portions of SMACNA, ICC, AHRI and AMACA standards and best practices.

Can this test method be used to create a field measured system baseline?

California Assembly Bill 802 allows an alternative energy savings method to include energy use measurement at the building meter. While the meter can identify excessive energy consumption, it cannot currently test and diagnose HVAC systems and identify needed repairs. This test method can fill that gap and operationalize the intent of the bill into action in the field by providing a pre-correction/upgrade performance baseline from which improvement efficiency can be measured and compared. Since the measurements are made at the HVAC system level, it does not meet the definition of a whole building metered energy savings methodology, but changes in energy usage and the resulting savings from system operation corrections and/or renovations are likely to be large enough to be detected at the building meter.

Are there uses for this testing outside of utility programs?

Currently more than 70% of technicians certified to use this test method operate outside of utility programs on a volunteer basis. It has been adapted for use in daily testing and diagnostics practices by service technicians, troubleshooters, engineers, commissioning agents and designers. Three versions of this test have been developed and implemented by the industry. The development of this specification and the ASHRAE SPC 221 standard will formalize, vet and improve the test method addressed by this data specification.