CQI FDS (Field Data Specification) Working Group
Meeting Minutes
Monday, October 2, 2017

Call to Order

The meeting was called to order at 11:04 a.m. PDT by Chair Pete Jacobs (BMI).

Welcome and Agenda Review

Chair Pete Jacobs (BMI) welcomed members. He reviewed the agenda items for the meeting after roll call.

AGENDA TOPICS	DISCUSSION LEADER
Welcome, Roll Call, and Approval of 9/13/17 Meeting Minutes	PJacobs / EGalawish
Review of Action Items from Last Meeting	PJacobs
Questions or Comments on Calculations Presented on 9/13/17	
Best Practices: 1. Temperature and Humidity Measurements 2. Static Pressure Measurements 3. Electric Power Measurements	
Next Steps for Working Group Next Meeting – October 23, 2017 – 11am-12pm PDT	EGalawish
Action Items and Adjourn	PJacobs

Roll Call and Approval of 9/13/17 Meeting Minutes

There was a quorum for approval of the September 13, 2017, Meeting Minutes.

Organization	First Name	Last Name	WHPA Category	P=Present
Voting Members				
ACCA (Air Conditioning Contractors of America)	Donald	Prather	Contractor Association	P
BMI (BuildingMetrics Inc.)	Pete	Jacobs	Energy Efficiency Program Consultant	P
Daikin Applied	Skip	Ernst	HVAC Manufacturer	P
NCI (National Comfort Institute)	Ben	Lipscomb	Educator, Trainer	P
	Rob	Falke	Educator, Trainer	P
SCE (Southern California Edison)	Steve	Clinton	California IOU	P
Guest				
ACCA (Air Conditioning Contractors of America)	Glenn	Hourahan	Contractor Association	P
SCE (Southern California Edison)	Lori	Atwater	California IOU	P
Staff				
Galawish Consulting Associates (Staff Support)	Elsia	Galawish	Energy Efficiency Program Consultant	P

Pete Jacobs (BMI) motioned to approve minutes and Rob Falke (NCI) seconded the motion. The 9/13/17 minutes were approved, with one abstention.

Review of Action Items from Last Meeting

- Distribution of QM Data Specs – Pete Jacobs (BMI) will incorporate final comments into QM Data Specs and distribute updated version to the CQM Committee by 10/9/17.
- Updated version of 9/13/17 presentation was distributed to the WG.
- Industry Expert on the Use of Instrumentation – Rob Falke (NCI) contacted a few manufacturers to report on instrumentation best practices, but their expertise is in instrumentation manufacturing and not in the use of instrumentation protocol. Rob Falke and Ben Lipscomb (NCI) led the discussion on this topic.

Questions or Comments on Calculations Presented on 9/13/17

Rob Falke (NCI) inquired about the mixed air temperature calculations and Pete Jacobs (BMI) noted that those specific calculations were not specifically discussed; however, the mixed air temperature calculations were indirectly discussed. The WG talked about energy balance around the mixing box, it was part of the formulation of the overall equation, but the mixed air temperature calculations were not broken out separately. This topic will be discussed later in the meeting.

Best Practices

Pete Jacobs (BMI) – These discussions will focus on issues and best practices around making some of the field measurements that are embedded both in our installation data spec and in calculation procedures discussed at the 9/13/17 meeting. PPT presentation is embedded below.

FD Spec Meeting 10-2-17 v3.pptx

1. Temperature and Humidity Measurements

The goal is to have the ability to simultaneously capture and record multiple temperatures and humidity conditions across the HVAC system being tested. The discussion focused on basic instrument specifications, measurement timing, and probe placement.

There are a few Basic Instrument Specifications issues – Ensuring good quality instrumentation, there is a tradeoff in terms of cost and accuracy. We need field data instruments that are affordable and yet rugged enough to be used in the field on a regular basis. There should be some minimum accuracy ranges, and some types of field accessories are required.

Measurement Timing – When a system is set to full cooling in the field, conditions will continually change. Therefore, we need to be mindful that the temp/humidity under test will change over the course of the test—individual measures will not work because by the time the last measurement is taken, the first measurement has changed. We therefore require strategies where we can make multiple simultaneous measurements using an array of sensors or data loggers. This allows us to obtain comparable values that are recorded more or less at the same time.

Probe Placement – There are issues with probe placement. Ensure we get good measurement so the actual quantity we measure is up to the specifications of the equipment we are using by placing the probe in the right spot.

Discussion:

Rob Falke (NCI) – In developing the ASHRAE 221P Standard, we looked hard across the industry and realized that in order to increase measurement accuracy, we've had to rely on some relatively new technology and instruments. The instrument on Slide 6 is a Testo Probe kit with temp/humidity tools. There are several different probes that read at once, gather info, and report direct to mobile devices. This increases the accuracy of the testing. A year ago, this technology was not available, and we are comfortable with it now that it has been proven in the industry. Because each instrument is different, we will only discuss the principles of the testing. He solicited feedback from the group.

Lori Atwater (SCE) – I am interested in data acquisition in the field by contractors and ways to improve performance measurements and want to know how viable these tools are on the residential side. The contractors continually state that they cannot afford diagnostic tools, that they know what are doing, and that they do not need those tools.

Rob Falke (NCI) – These tools are becoming reasonable such that the costs of basic diagnostics are being reduced. The tools are a tenth of the cost from three years ago; there is no excuse for not using these tools given their accuracy; they are not optional. Dry bulb thermometers are not good enough. There is a residential side to the specifications – proposed ASHRAE 221 Standard applies to both residential and commercial sectors.

Don Prather (ACCA) – I agree with him that these diagnostic tools are above and beyond ACCA 5 (minimum installation standards for the residential sector). When you can simultaneously measure something at the point, that is a better way of knowing what is going on with the piece of equipment/system.

Pete Jacobs (BMI) – There have been some real advances in wireless communicating arrays of instruments, and this is just a good example. The only difference is residential HVAC units do not have dedicated outside air, so that measurement is not needed, otherwise it is the same thing.

Don Prather (ACCA) – This is changing in some parts of the country.

Pete Jacobs (BMI) – On Slide 7, these are basic Temp/Humidity (T/H) instrument specs per proposed ASHRAE Standard 221 and are consistent with our pro forma thoughts on measurement accuracy. We are looking to simultaneously capture and record temperatures across the HVAC system being tested. Most of equipment to be considered will use a multi-sensor probe that can read both temperature and humidity within the same probe and read out in RH units or wet bulb or enthalpy. Specs also include minimum accuracy requirements which recognize the need to recalibrate instruments periodically. Part of the T/H specs includes recommended field accessories – 3/8" drill bit, drill bit sheath, or protection and test port plugs.

Rob Falke (NCI) – ASHRAE Standard 221 bases its specifications on what is in ASHRAE Standard 111 plus six other ASHRAE standards. We had to take the ASHRAE fundamentals – Test & Balance and Maintenance Standards – and compare those to the proposed Standard 221 to ensure consistency.

Pete Jacobs (BMI) – On Slide 8, it shows that there is equipment out there that can communicate wirelessly and make multiple simultaneous measurements. Portable data loggers (old school) – most common instrument is Onset Hobo series which combines T/H probe – same specs. Can use multiple of those but not as conveniently as newer devices. Still a methodology with same functionality.

Don Prather (ACCA) – Does this methodology exclude ECMS systems that would have sensors with the same accuracy?

Rob Falke (NCI) – I recommend that the testing individuals who use EMCS data verify the locations and the accuracy of the sensor.

Don Prather (ACCA) – I agree with him and add that one should check whether loggers/probes are calibrated correctly.

Best Practices for T/H Measurement includes:

- Capturing equipment or system conditions simultaneously – equipment entering and exiting conditions and system (zone) entering and exiting, using up to 3 supply registers, and up to 3 return grill locations.
- Capturing condenser entering conditions approximately 1" from face of condenser, out of direct sun, no more than 10 minutes before or after corresponding equipment or system conditions are captured.
- On split systems with outside air ventilation, fresh air intake may be located remotely from condenser, and conditions should be measured independently.
- On packaged unit ventilation, entering conditions may be considered same as condenser entering conditions.
- Measuring equipment supply air temperatures out of the line of sight of coils, heat strips, or heat exchangers that are energized and can affect the measurement by radiant heat transfer

Discussion:

Pete Jacobs (BMI) – Generally, measurements of air flow are made at each register and then a sample of registers is picked to get the T/H entering the space. That is the idea of multiple distributive measurements and so we want to spread those around.

Skip Ernst (Daikin Applied) – Caution that the surroundings make a difference. There must be a clear area around the unit or you possibly generate stratification and recirculation especially of the outside air.

Rob Falke (NCI) – There are some specific protocols in the proposed Standard 221 that address this. With training, technicians can understand what they are getting.

Pete Jacobs (BMI) – On supply return measurements, the tricky part is getting the probe in the center of duct (in the flow). On both the return/supply sides, watch for potential radiant effects, especially hot surfaces, that can skew the sensor and lead to inaccuracies due to radiant heating. At the register level, put probe up into ducts as it enters the register to ensure not getting entrainment of room air affecting the measurement. These are the basic directions on probe placement for T/H measurement.

Ben Lipscomb (NCI) – With regard to the "up to 3 supplies/3 returns" issue, in the proposed 221 Standard, you need to measure at least (1) 3 supplies and 3 returns or (2) the number of supplies and returns in the system, whichever is less. For example, if a system has 10 supplies and 2 returns, you will have to measure both returns and 3 supplies to comply with the Standard.

Don Prather (ACCA) – On very large systems, does the Standard then require a measurement on different trunks?

Pete Jacobs (BMI) – At this point, no. Somewhat subjective on how to select which registers to measure, but any thought on how to get a good representative sample of registers?

Don Prather (ACCA) – I recommend measurement on different trunks if there are three main branches or if there are six. This is a topic for the 10/23/17 CQI FDS WG Meeting.

Rob Falke (NCI):

a) Curbs are such a hidden source of energy loss. Curbs are so leaky, restrictive, and are generators of pressure drop that they will pull in outside air, attic air, and mix supply air with return air. So, when it comes to measuring around the curbs, there is a specific set of protocols that allows you to evaluate those tests. Can see an easy 25% loss in curbs alone in a bad scenario—watch out for bypass between supply and return—affects temperatures. Curb manufacturers are not aware of bypass/restrictions that will sometimes really impact air flow.
b) Keep temperature probes out of line-of-sight of heat strip and heat exchangers – affects temperature significantly. The possibility for errors needs to be pointed out to technicians, and the proposed 221 Standard specs provides for this type of training.

Mixed Air Temperature Measurement – A Special Case – This is the more problematic area of temperature measurement in the field.

Pete Jacobs (BMI) – RTU mixing boxes are small and not a lot of mixing goes on there. Data from lab tests from University of Nebraska's David Yuill indicates mixing problems. These tests include an array of temperature sensors measuring temperature entering cooling coil of small packaged RTU with an economizer as a function of economizer position. Data showed that when closed temps are fairly uniform that as it opens, there is a significant amount of stratification. The implications of the mixing problems include

a) air-side stratification – no uniform temperature or flowrate,
b) refrigerant-side stratification – refrigerant circuits "see" different air temperatures,
c) non-uniform exit superheat, and
d) entering wet bulb temperature (EWB) measurement for FDD – single point measurement inaccurate – need to make multipoint measurements or calculate the EWB based on outdoor air and return air flow and temperature measurements to obtain reliable FDD results.

There is not only stratification in terms of temperature but also stratification in terms of air flow across the face of the coil. This mixing problem is one that we have to keep working on.

Skip Ernst (Daikin Applied) – This problem cannot be solved by multiple point measurements because there are two variables. Temperature stratification and air flow stratification change with damper position, and it can be very volatile. For a solution, you have to find good places to measure airflow. Before the mixing, you can get good return air and outdoor air temps. The question is, "Can you get outdoor air flow or return air flow in total so you can subtract?" I think this is the best approach.

Don Prather (ACCA) – The only way to solve this problem is to use a hot wire anemometers array and then have a formula that takes the readings simultaneously and changes to volume and then puts the two together.

Rob Falke (NCI) – Is this a paper that supports "mixing" problems and solutions? I agree with Skip Ernst (Daikin Applied) about good return and outside air measurement and knowing which % those are and mathematically calculate using entering coil temp or enthalpy.

Ben Lipscomb (NCI) – I also agree with the idea by Skip Ernest (Daikin Applied) and Don Prather (ACCA) that using multiple hot wire anemometers is interesting. However, I have not seen any research on this. It may be a potential for future improvements.

Don Prather (ACCA) – The charts on Slide 12 document another problem—you can see damper leakage here, and there is no way to deal with that situation that I know of unless you block off dampers. The other issue is that you have to compensate for fan energy – the theory is very strong on this.

Pete Jacobs (BMI) – Some dampers can be pulling in up to 200% of required outside air which is consistent with the work that Robert Mowris (Verified) did in the lab.

Pete Jacobs (BMI) and Rob Falke (NCI) volunteered to find any paper published on the work done by David Yuill (University of Nebraska) and his graduate students in this area.

2. Static Pressure Measurements

Pete Jacobs (BMI) – This discussion includes manometer specifications, probe selections, test ports, and probe placement to get a good set of measurements. Slide 15 shows the basic specs for a decent digital manometer. Manometers must be calibrated according to NIST standards. Typically, manometers come with accessories, and there are several products on the market that will meet these requirements.

Best Practices for Static Pressure Measurement includes:

- Calibrating instruments annually.
- Ensuring that the face point of static pressure probe is placed directly into the air stream, parallel to airflow. Technicians must be trained to identify correct test locations.
- On units with economizer or outside air, measuring equipment entering static pressure at face of filter, downstream from economizer and return dampers.
- On units without economizer or fixed outside air, measuring equipment entering static at threshold of unit to curb adapter or duct.
- Measuring equipment exiting static at threshold of unit to curb adapter or duct. Ideally two (2) duct diameters downstream.
- Taking extra caution when measuring units with electric heat strips, ensuring instrument cannot contact element.
- For pressure sensor placement:
  a) technicians must be trained to identify correct test locations;
  b) avoid turbulence;
  c) point probe into the flow; and
  d) move probe to find minimum reading.

Discussion:

Rob Falke (NCI) – To ensure that you get a good static pressure reading, there is a set of tests to verify readings to determine whether they are good. Diagnosis goes beyond probe readings. Packaged units, depending on accessories, have to know where to measure static pressure and install your test port—ideally near the face of the filter and downstream from the economizer—but you have to look inside of the system to see what is there. Technicians need to be taught the conditions that affect that static pressure or it may be a garbage reading. Again, curbs are problematic. As you look at readings, there has to be the intelligence/training to know when there is a good reading. Do not drill around heat strips.

Skip Ernst (Daikin Applied) – Turbulence is a problem here. As you get close to the fan, there is an awful lot of turbulence in the air. There will be units where you will not get accurate measurements if the duct work coming off the unit is not straight.

Rob Falke (NCI) – I agree. It takes full knowledge—need trained technicians.

Pete Jacobs (BMI) – Does turbulence just affect the direction of the flow?

Rob Falke (NCI) – In theory, static pressure is a bursting pressure across the duct. It may be affected by velocity if not perpendicular to air flow, and it is far more constant than a velocity pressure that you would use to measure air speed.

Don Prather (ACCA) – You do not want to take either static or velocity measurement where there is turbulence because that means there is air going around in a circle. Want laminar flow to take good measurements.

Pete Jacobs (BMI) – Static pressure, in general, is used as a diagnostic metric to look at air flow and as a way to improve the system and consistency from previous testing.

Don Prather (ACCA) – It can also be used with the fan log to see what the CFM change has been since the last test, if you measure the CFM separately.

Lori Atwater (SCE) – Is it possible to have diagnostic tools similar to the smog testing on cars?

Rob Falke (NCI) – The technology is there but the cost is prohibitive.

Pete Jacobs (BMI) – Some equipment on the market has embedded fault detection diagnostics – not looking for system faults but equipment faults. Currently, AHRI is developing a standard that addresses how the diagnostic codes are displayed. As in smog testing, it will require a combination of direct measurements and a review of fault codes.

Don Prather (ACCA) – Contractors have the tools to do this but Rob Falke (NCI) noted that most contractors doing this are outside of the California programs.

3. Electric Power Measurements

Pete Jacobs (BMI) – This discussion is focused on instrument type, specifications, and reading timing. Of all the measurements, this one is the easiest. Basic specs – want to have equipment that can measure true electric power on a line that can have harmonics. Electrical power meters are to measure and interpret system watt consumption including true RMS power, with a measured power factor to perform this testing. These power meter requirements include a minimum accuracy level, along with specific field accessories. There are solid 3-phase power meters on the market that do a good job.

Best Practices for Electric Power Measurements—Metering Best Practices includes:

- Using true electric power meters, not volts, amps, and assumed power factor.
- Taking extra caution when measuring units with electric heat strips, and disabling strips before testing
- Using a 3-phase meter for 3-phase equipment since there are timing issues with multiple single-phase measurements.

Next Steps for Working Group

Last Meeting: Monday, October 23, 2017; 11:00 a.m. – 12:30 p.m. PDT
Draft Agenda: Agenda will focus on:

- Air Flow Measurements
- Overall Uncertainty

Action Items and Adjourn

Action Items

- Pete Jacobs (BMI) to incorporate final comments into QM Data Specs and distribute updated version to the CQM Committee by 10/9/17.
- Pete Jacobs (BMI) and Rob Falke (NCI) volunteered to find University of Nebraska's David Yuill's work and distribute to WG (data from lab tests which indicates mixing problem—see page 5).
- Comments on practicality of best practices in presentation should be sent to Pete Jacobs.

Adjourn

The meeting adjourned at 12:36 p.m. PDT.

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