## Summary

This document provides industry input on barriers which limit standardization of ACCA Standards 5 and 9-based quality residential HVAC installation and possible solutions to address these barriers.

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## Use of this Document

*This document provides industry input on barriers which limit standardization of ACCA Standards 5 and 9-based quality residential HVAC installation and possible solutions to address these barriers.*

*It is based on an official WHPA Work Product of August 22, 2012, titled "Residential QI Committee Report." This Work Product was developed by the WHPA Commercial Quality Maintenance 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@performancealliance.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.*

## Barriers and Solutions for Residential Quality HVAC Installation

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## Background

The Residential Quality Installation (QI) Subcommittee of the Western HVAC Performance Alliance (WHPA) developed the attached White Paper which highlights its observations on the market barriers impacting broader success for residential Quality Installation.

This paper presents specific recommendations required to transform the residential HVAC market from current standard design and installation practices based on "rules-of-thumb" to one where quality standards prevail.

## Executive Summary

The California Energy Efficiency Long Term Strategic Plan envisions a transformation of the HVAC industry to ensure that climate appropriate equipment is installed and maintained per industry established standards. This transformation is needed because market forces have contributed to the demise of quality over the past several decades such that the market expects value from every installation and there is no recognition for contractors who do the job right. Furthermore, despite the best efforts of Title 24, the current code lacks consistency with industry standards and has no effective enforcement mechanism resulting in the majority of the market blatantly ignoring its requirements. All of this has resulted in wasted energy and inadequate customer comfort.

This situation can be resolved through a concerted effort of the WHPA. The specific items that need to be addressed include:

1. **Program Implementation Barriers** – The current energy savings documented in DEER do not seem to provide an adequate incentive for utilities to sufficiently stimulate the market for the purpose of accelerating adoption of QI and QM. There is a cost required to overcome decades of industry complacency in the areas of training, mentoring, and compelling verification. In the absence of credit for providing the high level of contractor support required, utilities may be able to offer little more than a standard equipment replacement program.
2. **Program Participation Barriers** – Contractors have not adopted standards-based QI in large numbers because there is a significant cost to do so. Contractors must commit to technician training, purchasing instrumentation, lost business to contractors who are not willing to comply with QI standards and/or Title 24, and the risk of failing. Perhaps most importantly though is the fact that customers are not demanding the level of service required by the utilities and have not demonstrated that they are willing to pay for it. Customers are more likely to make purchasing decisions based on price rather than competence.
3. **Code Inconsistencies** – Title 24 needs to better align with industry standards. Much of what Title 24 has tried to do is regulate workarounds that simplify the design and installation process rather than create the provisions for enforcing industry standards.
4. **Verification Barriers** – Assuming that the necessary code improvements are made and an effective enforcement mechanism is created, then better trained HERS raters will be required to verify compliance with industry standards. The current crop of HERS raters have not been trained to the level required to confirm the proper design and commissioning of residential HVAC systems.

## Observations and Experiences

The recommendations included below are based on the collective experience of the Residential Quality Installation Subcommittee, which consists of consultants, contractors, trainers, and verifiers, many of whom are involved in the design, implementation, and participation of SCE's Residential Quality Installation program. The WHPA Executive Committee is strongly encouraged to consider these recommendations and authorize relevant Committees to develop work plans necessary to implement the recommendations.

## Recommendation #1: Improve Quality Installation Education

More effective training is required to position contractors to succeed with QI. Specific training recommendations include:

### Design Training

1. Design training should be based on the most current ACCA approved Manual J (version 8), D and S software. Due to California's diverse architectural features, few homes fit into the cookie cutter design that would allow for Abridged Edition (AE) design methods.
2. Due to the complexity of Manual J, S & D, training should incorporate commercially available load calculation software. Contractors respond to "Hands On" training versus lecture and read from book methods. Attendees in such a practical design class should be encouraged to have a licensed copy of the software and have basic computer skills in order to enroll; however the cost of such software presents a participation hurdle that must be overcome.
3. Trainers should be encouraged to pursue ACCA EPIC certification, and to have a minimum of 5 years working experience with approved load calculation software. Trainers should be competent and familiar with past and current construction practices and techniques, and familiar with current building codes and T-24 energy requirements.
4. HERS Providers should be encouraged to integrated design training into their training and certification requirements for raters.
5. Similarly, opportunities for design training for building officials for building officials should be pursued such that they can adequately review load calculations.

### System Commissioning Training

Technicians need to be competent in commissioning a system after it has been properly designed using Manual J, D, and S. The requirements for testing and commissioning of the system include the ability to measure evaporator air flow, refrigerant charge – both super heat and subcooling – duct leakage, electrical values and room-by-room air flows. Technicians should also be able to calculate the delivered capacity of the system using measurements taken during commissioning.

To validate a thorough understanding of the commissioning process, system commissioning training should culminate in a field examination performed in a house that has been designed by the contractor so the concepts of Manual J, D, and S can be brought to life after the installation.

Such a field examination should confirm that:

1. Technicians demonstrate they can commission a system in a specific order of operation to ensure making adjustments to one function of the system would not impact the other parts of the system. For example, duct leakage must be addressed before moving on to air flow and charge.
2. Technicians demonstrate competency in hands-on testing using their tools. Instruction in the proper use of the instrumentation should be offered to ensure the technician can demonstrate that they can perform all tests without assistance.
3. Technicians should possess a minimum set of properly calibrated tools required to take the measurements and use these in the class and exam. This creates yet another hurdle as a proper set of quality tools is costly for individual technicians. The recommended tool set includes:
    a. Duct leakage tester to measure duct leakage.
    b. Flow Hood, flow plates, and anemometer for measuring air flow. (No one tool is appropriate for all configurations.)
    c. Manometer for measuring static pressure.
    d. Compound digital manifold gauges for measuring refrigerant pressures.
    e. Pipe clamp thermocouples for measuring refrigerant pipe temperatures.
    f. Air temperature sensors capable of being inserted into the air stream and with the ability to measure wet and dry bulb temperatures.
    g. True RMS multi meter, preferably with a power factor function.
4. Technicians often don't understand the proper handling and calibration process for all the above tools. It is recommended that training on tool calibration be made readily available for technicians through multiple training channels.

**Verifier Training:**

Verifiers should possess the same level of competence as the technicians they are inspecting and realistically should have greater knowledge. Unfortunately the typical HERS raters that perform inspections are most often not HVAC technicians and lack sufficient knowledge or experience in system design and performance. HERS providers or other training channels should be encouraged to develop additional certification programs for HERS rater that provide the detailed knowledge required to verify compliance with Quality Installation standards.

The training and certification requirements discussed for technicians is also necessary for the HERS rater who verifies the technicians work. Additionally the verifier must be capable of identifying any discrepancies in the components used in developing the load calculation. These include:

1. Square footage and average ceiling height
2. Front door azimuth
3. Attic type
4. Ceiling type and insulation level
5. Wall type and insulation level
6. Floor type and insulation level
7. Window type and interior shading
8. Duct location and insulation level

**Recommendation #2: Increase Contractor Mentoring and Support**

One of the fundamental failures of the current training approach being delivered to the industry is the lack of a support infrastructure to contractors to help them apply the concepts they learned in their training program(s). Support is critical to ensure the technician will be able to solve unfamiliar circumstances they may encounter in the field. Specific areas of support that are needed include:

1. Contractors should have access to equipment capacity calculators. Manual S (equipment capacity) performance table interpolation is beyond the capabilities of most people without a math or engineering degree. Web-based tools with an "Entering Air" calculator, makes the Manual S procedure simple, repeatable and accurate. Due to the hot/dry environment in much of California, calculators should be able of interpolation to a Sensible Heat Ratio of 1.0. This will allow proper equipment selection and sizing per Manual S requirements in hot, dry climates.
2. Additional design support should be made available to contractors after initial load calculation training to build confidence in the procedures. No training can effectively answer all procedural questions due to the technical complexity of the Manual J, S & D procedures and the variety of building and system configurations encountered in the field.

Technical support could come from:

1. Design Reviewers: Support resources at the design level could be made available to the contractor either through distributors, HERS raters or through the local building departments.
2. Equipment Manufacturers and Distributors: Manufacturers and distributors are well positioned to support their contractor/dealer client regarding load calculation, equipment selection and air flow questions.
3. Verifiers: When technicians are on site during verification, any problems that arise can be pointed out and the technicians instructed on corrective actions and the cause for the problem can be investigated and resolved immediately.

**Recommendation #3: Make Code Enforcement More Effective**

Despite the best efforts of the California Energy Commission (CEC) and HERS providers, the current code enforcement process has not proven effective. Building officials do not have the resources to enforce Title 24 consistently across jurisdictions and there is no effective verification process that ensures systems are installed properly. The HERS process has been developed to confirm compliance with specific aspects of Title 24 (e.g. charge and duct leakage) but not to document compliance with all thirteen aspects of the ACCA Standard.

Initial enforcement could come in the form of an additional license classification for a "Residential HVAC Designer." This would require the development of an HVAC design test. Such a license requirement will assist building officials in verifying contractor HVAC Design qualification. If pursued, this activity will need to be coordinated with the Board for Professional Engineers, Land Surveyors and Geologists to ensure that the design classification does not conflict with the responsibilities of a Professional Engineer.

Additional enforcement could come from individual city planning departments. As envisioned by the California Energy Efficiency Strategic Plan, building permits should be pulled when required by law. The permit process provides a perfect opportunity to confirm Manual J load calculation, Manual S equipment selection procedure and, (where applicable), Manual D procedure. The ACCA Plan Review Form was developed to help plan check reviewers confirm load calculations and is auto generated by all approved software packages. During the field inspection process, inspectors should verify that the equipment documented in Manual S is installed on site. A commissioning form, such as the one developed by ENERGY STAR® for their national QI program should also be required as part of the permitting process.

**Recommendation #4: Improve Codes and Standards and Better Align Them with Industry Standards**

While the current codes and standards efforts address many aspects of quality installation, there are still many gaps in the standards that need to be addressed. Examples of such gaps include:

1. The next round of updates to ACCA QI5-2010 should consider the wisdom gained through years of QI program implementation. Some examples of issues realized in the practical implementation of the standard include 1) the need to specify a minimum airflow of 350 cfm per ton and 2) the need for additional clarification for Manual D and testing of zoned systems.

2. The current fan watt draw requirements in Title 24 should be revised to include a "Not to Exceed" External Static Pressure of 0.8 ESP design standard for all new duct systems. (Excluding Zoned VAV systems). Duct systems can be designed and installed to achieve a minimum static pressure, but fan watt draw is only a measurement that can be performed after installation and cannot be considered by the designer.

3. There should be an increased emphasis on "minimum airflow" across all codes, standards and efficiency programs. Delivered CFM = Delivered Capacity. A high percentage of existing systems deliver only 30% to 60% of their rated CFM, due to poorly designed and installed duct systems. This translates to 30% to 60% of their rated performance which grossly reduces efficiency and comfort. The opportunity to maximize delivered capacity should be taken whenever possible, but most efforts tend to be more focused on the equipment itself and not the entire system. Whole building and system approaches are consistent with the California Energy Efficiency Strategic Plan and should not be forgotten.

## ATTACHMENT
## HISTORY OF RESIDENTIAL QUALITY INSTALLATION

During the years leading up to the 2006 increase in the federal minimum efficiency equipment standards, the Environmental Protection Agency (EPA) and many electric utilities were looking at ways to increase air- conditioner and heat pump performance (i.e. energy savings). The forthcoming change from the SEER 10 to the SEER 13 standard essentially meant little upside room for SEER based energy savings available through typical equipment rebate programs.

The Cadmus Group, a vendor to the EPA at the time, put together a forward looking equipment specification standard that would help installers in testing and commissioning with the hope that it would allow for better testing and analysis (design/installation feedback and improved maintenance). This prototype standard was vetted by the EPA to Air-Conditioning, Heating and Refrigeration Institute (AHRI) and Original Equipment Manufacturers (OEMs) in 2005, as well as to utilities and other stakeholders in an annual EPA meeting in Chicago. The standard was designed to make systems more robust, testable and maintainable.

Feedback from stakeholders was positive; however, the OEMs contended that the prescriptive nature of the standard made products more expensive, thwarted innovation and didn't allow them to differentiate products. The prototype specifications for the proposed EPA equipment standard were dropped and discussions with ACCA and others ensued, focusing on formalizing standards for design and installation.

ACCA assembled a working standards group consisting of contractors, utilities, OEMs, and trade groups. ACCA published the first American National Standards Institute (ANSI) recognized Quality Installation Standard in 2007. Shortly thereafter, another Committee was formed to put together a verification standard to create the protocols necessary to provide quality assurance to ensure that the requirements of the quality installation standard were achieved.

The summary of these two standards products is:

1. ANSI/ACCA Standard 5 – Provides a list of the minimum steps and applicable procedures necessary to properly design, install and commission a mechanical comfort system.
2. ANSI/ACCA Standard 9 – Provides a structure to evaluate whether a contractor substantially performed the minimum steps outlined in the installation standard, acceptable minimum documentation, inspection and testing of systems installed to the standard if they are to be certified as meeting the installation standard.

With these two important standards developed, the EPA adopted them as the foundation to a new performance-based ENERGY STAR HVAC Quality Installation program and later also included in Home Performance with ENERGY STAR and the ENERGY STAR (new) Homes Programs.

**What is the QI Standard?**

The QI Standard is an industry consensus document which identifies the minimum steps necessary to design and install a mechanical comfort system by a mechanical contractor. It is not a document listing best-practices. During the Committee process, the term "Quality" was defined as "minimum competence."

The intent of the Committee in putting the QI Standard together was also to utilize as many existing standards as possible when it came to testing and verification. It should be pointed out that the standard often suggests 'acceptable" practices and ranges, but also utilizes language referring to OEM procedures and specifications because of the lack of published standards in the industry. The standard also provides and requires inclusion and consideration for local codes.

For the layperson, this may not seem too meaningful, but for the technician it is problematic because they still lack guidance, mentoring and feedback in practical applications of the QI Standard. For example, OEM installation documents will often cite Subcooling goals, but not Superheat goals, and most don't even define where to take the measurements. This becomes particularly problematic when there is both a service valve in the discharge line and at the outlet of the condenser coil, since either could be used to gather the estimated coil saturation temperature which is in turn used to calculate Subcooling. The definition of Superheat in many OEM documents often refers to the outlet conditions of the evaporator coil, but typically technicians are taught to measure it at the inlet to the compressor; few OEM documents suggest where to place sensors, therefore measurement techniques are usually practices learned in the field – right or wrong. Title 24 attempts to address the case of Superheat where systems utilize a TxV by prescribing a wide range of acceptable measured values (presumably at the inlet of the compressor), yet OEMs typically provide no guidance on acceptable values, nor the value the system was certified or expected to operate with.

Just as problematic is the fact that most OEMs publish system performance and design information in different formats and documents sources - some of which are not readily available. In some cases, OEMs do not provide design or operational information for hot, dry climates that are typical in California. This means that design practitioners utilizing the Quality Installation design procedures often have to go to great lengths to get the information needed for inputs into design software. In the absence of information they make educated guesses or select the closest values available, or use default code values. The reality of this is that design is an art, not a standards-based science, and therefore impractical to enforce without a great deal of knowledge and experience, or access to the "right" resources from OEMs.

Understanding the above, the Committee set forth an initial QI Standard with the knowledge that the QI Standard would need revisions as some of the "holes" were encountered and shored up. Also during the standards development process, concerns from California representatives made it clear that the standard would have no value to California if it didn't exceed the code requirements of Title 24.

Title 24 requires contractors to utilize the design procedures outlined in Manuals J, D and S, and even requires testing by a third-party; whereas the QI Standard requires the contractor to utilize the same design procedures, but to commission and document the results prior to any third-party verification. It is reasonable to assume that Title 24 implies that a contractor would have commissioned the system prior to HERS verification. In either case Title 24 and the QI standard are trying to achieve the same

thing with the notable differences in that Title 24 spreads responsibility across several parties, and the QI Standard makes it solely the contractor's responsibility.

Nothing in Title 24 requires contractors to implement better design and installations than simply minimizing duct leakage (which of course is important) in some climate zones. There are currently no natural feedback signals to the HVAC trades to either supply competent designers or technicians who can implement a given design. Title 24 provides no mechanism to ensure Manual J load calculations are performed correctly, nor that the duct system is designed to deliver sufficient velocity at the lowest possible static pressures, nor that the equipment or fan speeds were selected correctly. In fact, Title 24 cites specific airflow requirements irrespective of design requirements or equipment capabilities.

The QI Standard requires contractors to produce reviewable design documents, and leave them with the building owner/operator for peer review at any time. The contractors and their technicians are responsible for system performance, not just a surrogate indicator such as Superheat or Subcooling goals. Contractors are required to measure capacity and efficiency. When systems are performing, this opens an immediate dialog with distributors and OEMs, which in turn provides them with important information to correct problems and make products better. Because contractors will actually be required to do the designs and test systems, the industry will get the feedback signal that it needs to provide training in the trade schools on design and testing whereas the current environment generally provides this training well after a contractor or technician are established in the industry.

**So what does this mean for savings?**

The premise of Title 24 is that codifying proper methods and confirming performance in some method results in better overall mechanical system performance. In fact the "end game" for many utility sponsored programs is to prepare the market for advancements in code – so most would agree that Title 24 is a win. The downside is that when you advance a code before the market can deliver it, especially when the requirements are complex, you will get little to no code compliance – which is what has happened in California.

When the QI Committee was grappling with the name "Quality Installation Standard," the question of how many contractors in the nation could comply with the standard arose. The room fell silent and several whispers of "none" to "maybe 2% - if motivated enough" were the answers. The Committee kept the name "Quality Installation Standard" in spite of the realization that it is really the "Minimum Competent Standard" because it needed to have market value. California Title 24 has been trying to get contractors to perform most of the QI Standard for many years in spite of the lack of training and field guidance infrastructure. Other than in a few isolated instances, the industry is not set up to do this anywhere in the nation (with any degree of completeness) – including California. Low code compliance estimates in California indicate that the current process is broken.

The savings that can be achieved from the QI Standard result from smaller equipment sizing (lower installed kW), lower static pressures (lower fan power kWh), and lower duct losses (delivering conditioned air where it needs to be). Although we could argue the baseline is Title 24, and the code already requires QI, the reality is that low compliance rates combined with experience from QI programs throughout the country illustrates that the "true" baseline is purely one of "rules-of-thumb." The bottom line is that there is little to no engineering of residential systems (particularly for system replacements) because the sale of equipment has become commoditized, and there is no real quantification of the benefits of a properly designed and installed system.

California already values the potential savings of QI as it was essentially codified in Title 24; however current QI programs have demonstrated that the market is largely unable to install to QI Standards without a robust training and support network and effective verification. Baseline is the normal day-to-day installation practices that contractors install to, not what Title 24 hopes it should be.

When contractors and their staffs are given enough instruction and support and there is a credible verification process that assists contractors rather than penalize them, then they are able to achieve QI Standard levels (and hence truly conform to the intent of Title 24). The current HERS compliance methods do not provide the mechanisms required to ensure compliance with load calculation, duct design or equipment selection issues desired by Title 24. Without significant changes, QI will not be achieved as the "market norm" and the Big Bold Plan to transform the industry will fail to address this important component.