AIR CONDITIONING CONTRACTORS OF AMERICA

2800 Shirlington Road
Suite 300
Arlington, VA 22206

703.575.4477
Fax 703.575.8107

www.acca.org

ACCA Standard

STANDARD NUMBER: ANSI/ACCA 5 QI–2007

HVAC Quality Installation Specification

Residential and Commercial Heating, Ventilating, and Air Conditioning (HVAC) Applications

The Air Conditioning Contractors of America Educational Institute (ACCA-EI) Standards Task Team (STT) develops standards as an American National Standards Institute (ANSI) accredited standards developer (ASD). ACCA develops voluntary standards as outlined in the ACCA Essential Requirements and the ANSI Essential Requirements. ACCA standards are developed by diverse groups of industry volunteers in a climate of openness, consensus building, and lack of dominance (e.g., committee/group/team balance). Essential requirements, standard activities and documentation can be found in the standards portion of the ACCA website at www.acca.org. Questions, suggestions, and proposed revisions to this standard can be addressed to the attention of the Standards Task Team, ACCA, 2800 Shirlington Road, Suite 300, Arlington, VA 22206.

ACCA Standards are updated on a five-year cycle. The date following the standard number is the year of approval release by the ACCA-EI Standards Task Team. The latest copy may be purchased from the ACCA online store at www.acca.org or ordered from the ACCA bookstore via toll-free telephone at 888.290.2220.

Approved American National Standard
ANSI

www.ansi.org

2800 Shirlington Road, Suite 300
Arlington, VA 22206
www.acca.org

Adoption by Reference

Public authorities and others are encouraged to reference this document in laws, ordinances, regulations, administrative orders, or similar instruments. Any deletions, additions, and changes desired by the adopting authority must be noted separately. The term "adoption by reference" means the citing of title and publishing information only.

Disclaimer and Legal Notice

Diligence has been exercised in the production of this standard. The content is based on an industry consensus of recognized good practices. The commentary, discussion, and guidance provided by this publication do not constitute a warranty, guarantee, or endorsement of any concept, observation, recommendation, procedure, process, formula, data-set, product, or service. ACCA, members of the Standards Development Committee, Standards Task Group, members of the Standards Task Team, and the document reviewers do not warrant or guarantee that the information contained in this publication is free of errors, omissions, misinterpretations, or that it will not be modified or invalidated by additional scrutiny, analysis, or investigation. The entire risk associated with the use of the information provided by this standard is assumed by the user.

ACCA does not take any position with respect to the validity of any patent or copyrights rights asserted in connection with any items, process, procedures, or apparatus which are mentioned in or are the subject of this document, and ACCA disclaims liability of the infringement of any patent resulting from the use of or reliance on this document. Users of this document are expressly advised that determination of the validity of any such patent or copyrights, and the risk of infringement of such rights, is entirely their own responsibility. Users of this document should consult applicable federal, state, and local laws and regulations. ACCA does not, by the publication of this document, intend to urge action that is not in compliance with applicable laws, and this document may not be construed as doing so. Nothing in this standard should be construed as providing legal advice, and the content is not a substitute for obtaining legal counsel from the reader's own lawyer in the appropriate jurisdiction or state.

ACKNOWLEDGEMENTS

ACCA gratefully acknowledges the direction, guidance and encouragement provided by the diverse expertise embodied in the membership of the Quality Installation Specification Committee:

CONTRACTORS	Robert Feathers (B. F. Mechanical; Centerville, OH) Gregory J. Goater (Isaac Heating and Air Conditioning; Rochester, NY) Joe Presley (Tri-City Mechanical; Chandler, AZ) Larry D. Sambrook (Indoor Air Quality Network; Stanton, VA) Mitchell Slavensky (ACS Controls Corporation; McClellan, CA) Skip Snyder (Snyder Company; Celebration, FL)
UTILITY PROG. ADMINISTRATORS	John Jones (New York State Energy Research and Development Authority; Albany, NY) David P. Manoguerra (Pacific Gas and Electric Company; San Francisco, CA) Christopher Neme (VEIC/NEEP; Burlington, VT) R. Anthony Pierce (Southern California Edison; Irwindale, CA) Michael G. Stephens (TXU Electric Delivery; Bullard, TX) Buck Taylor (Massachusetts CoolSmart™ Program; North Easton, MA)
OEMS	Gary E. Georgette (Carrier Corporation; Indianapolis, IN) Raymond Granderson (Rheem Manufacturing; Fort Smith, AR) Joe C. Leonard, Jr. (Allied Air Enterprises; Blackville, SC) James W. Muncie (American Standard Corporation; Tyler, TX) Hung M. Pham (Emerson Climate Technologies; Sidney, OH)
ASSOCIATIONS & OTHERS	Glenn C. Hourahan, P.E. (Air Conditioning Contractors of America; Arlington, VA) Patrick L. Murphy (North American Technician Excellence; Arlington, VA) William J. Parlapiano, III, CIAQ (Building Performance Institute; Malta, NY) Harvey M. Sachs, Ph. D. (American Council for an Energy-Efficient Economy; Washington, DC) Frank Stanonik (Gas Appliance Manufacturers Association; Arlington, VA) John Taylor (Consortium for Energy Efficiency; Boston, MA) Chandler von Schrader (Environmental Protection Agency / Energy Star; Washington, DC)

Special acknowledgments and appreciation go to Skip Snyder as Chair of the Committee, as well as to Subcommittee Chairs - Gregory Goater, Christopher Neme, and Mitchell Slavensky. Additionally, special thanks to John Taylor for his assistance and contributions to the development of this specification.

ADDITIONAL ACKNOWLEDGEMENTS

This document has received helpful comments and input from numerous knowledgeable individuals. These included:

Jerry Adams (TXU Electric Delivery; Dallas, TX)

Linda Cavalluzzi (Long Island Power Authority, Long Island, NY)

Christine Colditz (Laco Mechanical Services; Elk Grove Village, IL)

David Dugger (Shoffner Mechanical & Industrial; Knoxville, TN)

Janis Erickson (Sacramento Municipal Utility District; Sacramento, CA)

Glenn Friedman, P.E. (Taylor Engineering; Alameda, CA)

James E. Gilroy (PacifiCorp; Portland, OR)

Ellis G. Guiles, Jr. P.E. (TAG Mechanical Systems, Inc.; Syracuse, NY)

Larry Jeffus (consultant to TXU Electric Delivery; Dallas TX)

Tom Kavounas (Albemarle Heating & Air; Charlottesville, VA)

Joseph Kounen (Building Performance Institute; Malta, NY)

Warren Lupson (Lupson & Associates; Silver Spring, MD)

Arthur T. Miller (Community College of Allegheny County; Pittsburgh, PA)

Wayne W. Mulholland (Tri County Mechanical; Azle, TX)

John Parker (retired: Alabama Power Company; Verbena, AL)

John Proctor (Proctor Engineering Group; San Rafael, CA)

Maggie Ramos (Long Island Power Authority, Long Island, NY)

Thomas A. Robertson (Baker Distributing Company; Jacksonville, FL)

Leslie Sandler (consultant; Fairfax Station, VA)

Dick Shaw (Air Conditioning Contractors of America; Arlington, VA)

Bruce Silverman (Airite Air Conditioning; Tampa, FL)

William W. Smith (Elite Software; College Station, TX)

David Swett (HVAC Training Center; Omaha, NE)

Neil Sybert (San Diego Gas & Electric; San Diego, CA)

Surumi J. Thorpe-Hudacsko (Silver Spring, MD)

Peter M. Van Lancker (Rheem Air Conditioning; Fort Smith, AR)

Martin J. Weiland, P.E. (Alexandria, VA)

Richard F. Welguisz (Trane; Tyler, TX)

Richard Wirtz (Heating, Airconditioning & Refrigeration Distributors International; Columbus, OH)

Tom Yacobellis (Ductbusters Incorporated; Dunedin, FL)

FOREWORD

[This Foreword is not part of the standard. It is merely informative and does not contain requirements necessary for conformance to the standard.]

Market Conditions

A significant market opportunity for improving the quality of HVAC equipment installations and service involves raising the awareness of consumers and building owners / operators about the benefits provided by professional contractors following industry-recognized quality installation practices (e.g., correct equipment selection, installation, and commissioning). Building owners / operators and residential consumers need to be informed of the links between comfort, humidity levels, utility bills, and indoor air quality with a proper HVAC system design and installation. Once aware, consumers will better understand the value of a high performance standard from their HVAC contractor. This understanding will also help position consumers and building owners / operators to consider the complete value-to-cost equation, not merely the "first price," when making HVAC equipment purchasing decisions. Customers who select contractors that promote high performance HVAC equipment – and their proper installation – enjoy enhanced comfort, reduced energy usage, improved occupant productivity, and enhanced occupant safety.

Of the 7.1 million unitary shipments reported by the Air Conditioning and Refrigeration Institute (ARI) for 2006, approximately 60% were for replacements. Many of these installations were the result of equipment failures during peak periods (i.e., winter for furnaces and summer for air conditioners). During times of unanticipated equipment failures, consumers often demand service attention that cannot be fully met by normal contractor staffing levels. This issue is compounded by a shortage of qualified technicians, especially experienced during seasonal crunch times. Furthermore, consumers generally tend to request only the level of comfort and efficiency delivered by their previous system. Given that consumers want the heating or cooling to be restored, and that contractors feel pressure to replace the equipment quickly, technicians have an incentive to focus more on the turn-around time of the jobs rather than on the quality of the jobs. Exacerbating this situation is the fact that few consumers plan for such emergencies. This results in a financial crisis in which the "first cost" of equipment is considered more important than full "life-cycle costs." The building owner's/operator's failure to link comfort and operating costs with substandard design and installation can be tied to the industry's general lack of performance in raising awareness. The market currently provides no signal to the contractor or the building owner / operator that system performance is poor until the system fails.

Due to poor understanding by building owners / operators of the value that professional contractors and quality installations offer, there is a consumer market for an unlicensed, or poorly trained, or otherwise unqualified individual or business to install HVAC systems. Unlicensed, unskilled, unscrupulous, or non-caring contractors are inclined to cut corners and to offer prices and performance promises that are difficult for professional, qualified contractors to match. Uninformed consumers are left to experience the inevitable inconveniences and expenses of a poorly designed and poorly functioning HVAC system. Manufacturers experience higher warranty costs, and utilities face escalating demand for power. Additionally, many of these under-qualified/non-professional contractors will often provide valueless warranties, have little or no insurance, and create poor perceptions of the industry in the consumer's eyes.

Industry Need

There is a need to establish a raised bar to improve the core competencies of contractors to ensure that quality installations ensue. This is beneficial not only as a process improvement for contracting businesses, but, more importantly, for fulfilling the needs of building owners/operators in quality installations – comfortable, healthy, safe, energy-efficient indoor environments. Yet, until now, across the broad spectrum of the industry (manufacturers, distributors, contractors, user groups, customers, utilities, environmental groups, associations/professional societies, governmental agencies, etc.), there has been no universally accepted definition of a quality contractor or a quality installation.

Full observance of the quality installation elements may increase the initial "cost" to the residential or commercial building owner/operator. However, the increased "value" – resulting from improved energy efficiency, better comfort, enhanced IAQ, improved equipment reliability, longer equipment life, etc. – is expected to far exceed any added upfront price. Additionally, adherence to the elements in this specification provides intangible societal benefits in the form of reduced power grid energy demand that aids in reducing pollution and dependence on foreign oil.

Specification Intent

This specification has been written with the intent that various HVAC industry stakeholders may use the criteria in diverse manners. Examples include:

- Contractors – to demonstrate their commitment to quality HVAC installations in residential and commercial building applications
- Equipment manufacturers – to highlight and encourage quality contractor practices, resulting in better equipment performance and durability
- HVAC trainers – to assist in the ongoing development of appropriate course curricula and training programs
- Utilities – to integrate the recommendations into their incentive programs
- Building owners/operators – to identify quality contractor practices and to ensure that quality installations are received

Additionally, the specification provides guidance to the U.S. Environmental Protection Agency (EPA) as it develops and maintains its EnergyStar™ installation program(s).

INTRODUCTION

[This Introduction is not part of the standard. It is merely informative and does not contain requirements necessary for conformance to the standard.]

The HVAC Quality Installation Specification was developed with a great deal of contribution from interested stakeholders. A coalition of contractors, original equipment manufacturers (OEMs), utilities, and industry associations collaborated to establish a set of nationally accepted requirements for "quality installations" (QI). Requirements, acceptable procedures, and acceptable forms of documentation are also presented, specifying how these QI attributes are to be quantified.

In this specification, the QI elements focus on the actual installation and how well the equipment is selected and installed. Quality installation is more than just using high-efficiency products and systems. The correct selection of equipment, controls and proper installation have a large impact on occupant satisfaction and energy savings. For this specification, core areas that characterize a quality installation include:

Equipment Aspects:
- Building heat gain/loss load calculations
- Proper equipment capacity selection
- Matched systems (splits only)

Equipment Installation Aspects:
- Airflow across the indoor coil
- Refrigerant charge
- Electrical requirements
- On-rate for gas- fired equipment
- Combustion venting system
- System controls

Duct Distribution Aspects:
- Duct leakage
- Airflow balance

System Documentation and Owner Education Aspects:
- Proper system documentation to the owner
- Owner/operator education

This document, focusing on new installation requirements, assumes that HVAC equipment and components are in new, factory clean condition. However, if the HVAC equipment is operated during construction phases, or otherwise allowed to deviate from normal cleanliness and/or maintenance parameters, then the newly-installed HVAC systems may not perform as expected even when proper installation procedures are observed. In these instances, it will first be necessary to restore the equipment cleanliness/condition before functional testing and verification is undertaken. Users of this specification are encouraged to review the references in Appendix 4 pertaining to HVAC system maintenance and cleaning.

This specification details a level of performance that, if satisfactorily achieved, serves as an indicator that sound industry practices were likely used during the design and equipment installation phases. Users of this document are advised to consider additional good practices not provided in the body of this specification. An illustrative list of additional important good practices and considerations is presented in Appendix 1. Appendix 3 addresses management and documentation practices that contractors may find advantageous in positioning themselves to deliver quality installations on a consistent basis in the field. Finally, Appendix 4 highlights other references that may aid in the design, installation, servicing, maintenance, and cleaning of HVAC systems.

TABLE OF CONTENTS

1.0 PURPOSE

This specification establishes minimum criteria for use by stakeholders concerned with the proper installation, maintenance, and servicing of HVAC systems to meet occupant demands for energy efficiency, comfort, and IAQ in residential and commercial applications.

2.0 SCOPE

This specification applies to HVAC equipment/components being installed in residential and commercial buildings:

2.1 EQUIPMENT APPLICATION

2.1.1 Residential Equipment:

a) Unitary air conditioners and air-source/water-source heat pumps up to 65,000 BTU/H
b) Furnaces (gas-fired, oil-fired, electric, and other) up to 225,000 BTU/H
c) Boilers up to 300,000 BTU/H

2.1.2 Commercial Equipment:

a) Unitary equipment (packaged and split) greater than 65,000 BTU/H
b) Furnaces greater than 225,000 BTU/H
c) Boilers greater than 300,000 BTU/H
d) Residential equipment used in commercial three-phase applications.]

Note: Due to differing design aspects and control/operation situations, built-up systems (i.e., chillers, custom or specialty-built penthouse units, etc.) are not included in this specification. Buildings employing built-up systems are generally designed by architects or professional engineers. Additionally, commercial buildings using built-up equipment are more likely to benefit from increased owner scrutiny via building commissioners, owner agents, etc.

2.2 EQUIPMENT SYSTEMS / COMPONENTS

2.2.1 Heating Systems / Components – Single Zone and Multizone

a) Heating-only equipment and heat pumps
b) Hot-water coil and/or fin-tube radiation, and/or unit heaters, and/or unit ventilators
c) Electric resistance coil and/or fin-tube radiation, and/or gas unit heaters, and/or unit ventilators
d) Hot air heating (fossil fuel or electric furnace, direct-fired and indirect-fired makeup air equipment)
e) Radiant heat equipment

2.2.2 Cooling Systems / Components – Single Zone and Multizone

a) Cooling-only equipment and heat pumps
b) Rooftop single zone, rooftop multi-zone (hot-deck/cold-deck)
c) Single-zone unitary (packaged terminal air conditioners/heat pumps, split-coil-ductless)

3.0 EQUIPMENT ASPECTS

This section focuses on the upfront design procedures/tasks undertaken before the equipment is actually installed.

3.1 BUILDING HEAT GAIN / LOSS LOAD CALCULATIONS

The contractor shall ensure that heat loss and heat gain load calculations are performed for every HVAC system installation/replacement.

3.1.1 REQUIREMENTS

The contractor shall provide evidence that:

a) For NEW residential and commercial buildings, or when adding new ducts to an existing structure, room-by-room heat gain/loss load calculations are completed
b) For EXISTING residential and commercial buildings, without contractor modification of the existing duct system, block load heat gain/loss load calculations are completed

Notes: For EXISTING BUILDINGS:
- Load calculations are not required if the original use of the structure has remained unchanged from that noted in the original engineering design plans and/or original load calculations.
- Room-by-room load calculations may be undertaken if so chosen by the contractor.

3.1.2 ACCEPTABLE PROCEDURES

The contractor shall perform one or all of the following acceptable procedures for fulfilling the desired criteria:

a) Follow an appropriate methodology/procedure to perform building load calculations (e.g., ACCA Manual J®, ACCA Manual N®, ASHRAE Handbook Guidelines, DOE EnergyPlus™, or other approved equivalents per the authority having jurisdiction)
b) Confirm that the calculations were performed (whether by the contractor or a qualified third party)

3.1.3 ACCEPTABLE DOCUMENTATION

a) Load calculation worksheets included in the job file, OR
b) Appropriate documentation in job file

3.2 PROPER EQUIPMENT CAPACITY SELECTION

The contractor shall ensure that all equipment is properly sized and selected prior to being installed.

3.2.1 REQUIREMENTS

The contractor shall provide evidence of the following:

a) For CENTRAL AIR CONDITIONERS and HEAT PUMPS - the sensible and latent capacity of the selected equipment will satisfy the building sensible and latent load requirement at representative operating conditions
   i. Manufacturer product data verify that application latent loads are addressed
   ii. Total equipment capacity between:
      - 95% and 115% of calculated system load (for air conditioners and heat pumps)
      - 95% and 125% of calculated system load (for heat pumps with winter heating dominated requirements)
      - OR the next largest nominal piece of equipment that is available for either

b) For gas-fired or oil-fired WARM AIR SYSTEMS and HEATING BOILERS - the heating capacity of the selected equipment will satisfy the heating requirement at design conditions
   i. WARM AIR SYSTEMS - output capacity between 100% and 140% of calculated system load unless dictated by the cooling equipment selection OR customer needs
   ii. HEATING BOILERS - equipment capacity between 100% and 115% of calculated system load, OR the next largest nominal piece of equipment that is available

3.2.2 ACCEPTABLE PROCEDURES

Using OEM performance information and industry-approved procedures (e.g., ACCA Manual S® for residential applications, ACCA Manual CS® for commercial applications, OEM guidelines, or other approved equivalent per the authority having jurisdiction), the contractor is to confirm that the selected equipment satisfies/meets the load requirements at the system design conditions.

3.2.3 ACCEPTABLE DOCUMENTATION

a) Equipment performance information in the job file
b) Documentation indicating the application objectives were met
c) Written job documentation or checklist in job file

3.3 MATCHED SYSTEMS

The contractor shall ensure that all evaporators, condensing units, and furnaces are properly matched systems as identified by industry-recognized certification programs.

3.3.1 REQUIREMENTS

The contractor shall provide evidence of matched systems according to one or more of the following for the pertinent equipment being installed:

a) ARI Product Certification directory/database (www.aridirectory.org)
b) CEE directory of ARI-verified equipment (www.ceehvacdirectory.org)
c) Gas Appliance Manufacturers Association (GAMA) directory/database (www.gamapower.org)

3.3.2 ACCEPTABLE PROCEDURES

The contractor shall use one or both of the following acceptable procedures for fulfilling the desired criteria:

a) Confirmation of system matching compliance as compared to a recognized product certification database
b) Confirmation of the matched system operational performance data to OEM documentation for all equipment being installed (i.e., air handling unit, indoor coil, outdoor condensing unit)

3.3.3 ACCEPTABLE DOCUMENTATION

a) Copy of the ARI, CEE-ARI, and/or GAMA certification record/certificate with appropriate reference number indicated for the matched system
b) Copy of OEM-provided catalog data indicating acceptable combination selection and performance data

4.0 EQUIPMENT INSTALLATION ASPECTS

This section focuses on the HVAC system installation.

4.1 AIRFLOW ACROSS INDOOR HEAT EXCHANGERS

The contractor shall verify that the airflow across the indoor heat exchanger is within acceptable ranges.

4.1.1 REQUIREMENTS

The contractor shall provide evidence of the following for the measured airflow across the indoor heat exchanger for installed systems (with all accessories and system components in place) [1]:

a) For cooling coil (e.g., refrigerant, water) and heat pump applications
   i. Airflow across the coil, at fan design speed and full operating load, is within 15% of the airflow required per the system design. and
   ii. Airflow across the coil is within the range recommended by the OEM product data[2]
b) For gas- or oil-fired heat exchanger applications
   i. Airflow, across the heat exchanger, at fan design speed and full operating load, is within 15% of the airflow required per the system design.
   ii. Airflow across the indoor heat exchanger is within the range recommended by the OEM product data
   iii. Heat exchanger airflow requirements shall be considered separately from any combined and attached cooling coils sharing the same distribution duct system.

4.1.2 ACCEPTABLE PROCEDURES

The contractor shall test using one or all of the following acceptable devices for fulfilling the desired criteria:

a) Pressure matching method[3]
b) An anemometer (e.g., hot wired, rotary style) or other methods (e.g., transverse pitot tubes) for measuring total static and velocity pressures to determine airflow velocity in several traversing locations per AABC, NEBB, or ASHRAE procedures
c) Flow grid measurement method
d) A manometer to determine the pressure drop across a clean cooling coil or fan coil unit and compare with values from the OEM CFM/pressure drop coil tables

---

1 When verifying airflow at full design fan speed, there is little distinction between a split capacitor fan motor (PSC) or a variable speed fan motor (e.g., electronically commutated motor; ECM). See "Fan Airflow" in Appendix B. Note: ECM fan motors are designed to modify their RPMs in order to provide a prescribed (programmed) air volume in response to static pressure conditions (actually torque on the output shaft). Hence, an ECM may use more or less power than a comparable PSC motor in the same application.

2 Airflow across the coil is typically between 350 to 450 CFM per ton

3 Use of a calibrated fan to match the supply plenum pressure and measure the system airflow through an active fan.

e) The temperature rise method (for heating equipment only – gas or oil furnace, electric heat) to verify proper airflow across the heat exchanger or heater elements. [Note: It is not acceptable to use the temperature rise method for cooling (i.e., airflow over the indoor coil).]

4.1.3 ACCEPTABLE DOCUMENTATION

a) Documented field data and calculations recorded on start-up sheet
b) Documented field data and calculations recorded on service records
c) Written job documentation or checklist in job file

4.2 REFRIGERANT CHARGE

The contractor shall ensure that the HVAC system has the proper refrigerant charge.

4.2.1 REQUIREMENTS

The contractor shall provide evidence of the following for charging installed systems:[4]

a) For the SUPERHEAT method, system refrigerant charging per OEM charging data/instructions and within ± 5°F of the OEM-recommended optimal refrigerant charge
b) For SUBCOOLING method, system refrigerant charging per OEM charging data/instructions and within ± 3°F of the OEM-recommended optimal refrigerant charge
c) Any method approved and specifically stated by the OEM that will ensure proper refrigerant charging of the system

4.2.2 ACCEPTABLE PROCEDURES

The system shall be charged according to an approved/acceptable charging method. The charging method used should be documented, including:
- system conditions
- calculations conducted
- results obtained

If ambient conditions require a follow-up visit to finalize the charging process, this should be recorded both at the initial visit and the follow-up visit.

The contractor shall use one or all of the following acceptable procedures for completing the desired measurements after confirmation of required airflow over the indoor coil per §4.1:

a) Superheat test done under outdoor ambient conditions, as specified by the OEM instructions (typically, 55°F drybulb temperature or higher)
b) Subcooling test done under outdoor ambient conditions, as specified by the OEM instructions (typically, 60°F or higher)

[4] Refrigerant charge tolerances noted (i.e., ± 5°F and/or ± 3°F of the OEM-recommended optimal refrigerant charge) are not additive to any OEM-specified tolerances.

4.2.3 ACCEPTABLE DOCUMENTATION

a) Documented field data AND operating conditions recorded on start-up sheet
b) Documented field data AND operating conditions recorded on service records
c) Written job documentation or checklist in job file

4.3 ELECTRICAL REQUIREMENTS

The contractor shall ensure all electrical requirements are met as related to the installed equipment.

4.3.1 REQUIREMENTS

The contractor shall provide evidence of the following:

a) LINE and LOW VOLTAGES per equipment (single and three-phase) rating plate - the percentage (or amount) below or above nameplate values are within OEM specifications and/or code requirements
b) AMPERAGES per equipment (single and three-phase) rating plate - the percentage (or amount) below or above nameplate values are within OEM specifications and/or code requirements
c) LINE and LOW-VOLTAGE wiring sizes per NEC (National Electric Code) or equivalent
d) GROUNDING/BONDING per NEC or equivalent

4.3.2 ACCEPTABLE PROCEDURES

The contractor shall test using the following acceptable procedures for fulfilling the design criteria:

a) Volt meter to measure the voltage
b) Amp meter to measure the amperage
c) Verify measurements with nameplate and over current protection criteria

4.3.3 ACCEPTABLE DOCUMENTATION

a) Documents showing that selections are in compliance with OEM specifications
b) Written job documentation or checklist in job file

4.4 ON-RATE FOR FUEL-FIRED EQUIPMENT

The contractor shall ensure the equipment “on-rate” (BTU/H input during steady-state operation) for gas-fired or oil-fired equipment is at the equipment nameplate value.

4.4.1 REQUIREMENTS

a) Gas-Fired Equipment:

The contractor shall provide evidence of the following:

i. Firing rate within ± 5% of nameplate input for gas equipment (or per OEM specifications)
ii. Temperature rise per nameplate

b) Oil-Fired Equipment:

The contractor shall provide evidence of the following:

i. Correct nozzle flow rate and spray angle for correct firing rate per nameplate input,
ii. Correct oil pump pressure for nozzle installed and at OEM's specified values, and
iii. Temperature rise per nameplate

4.4.2 ACCEPTABLE PROCEDURES

a) Gas-Fired Equipment:

The contractor shall test using both of the following acceptable procedures for fulfilling the desired criteria:

i. Clocking the meter or other fuel input measurement per OEM instructions, and
ii. Measuring the temperature rise at steady state conditions (with airflow first verified by §4.1) – furnaces only.

NOTE: Combustion analysis may be necessary in some cases.

b) Oil-Fired Equipment:

The contractor shall fulfill the following criteria

i. Verify nozzle or alternate input nozzle per OEM installation or oil burner instructions.
ii. Adjust oil pump pressure with a dial or electronic gauge designed for oil pressure measurement
iii. Measure the temperature rise at steady-state conditions (with airflow first verified by §4.1) –furnaces only.
iv. Perform a combustion analysis per OEM installation or oil burner instructions.[5]

4.4.3 ACCEPTABLE DOCUMENTATION

a) Documented field measurements
b) Written job documentation or checklist in job file

4.5 COMBUSTION VENTING SYSTEM

The contractor shall ensure proper sizing, design, material selection and assembly of the combustion gas venting system.

4.5.1 REQUIREMENTS

The contractor shall provide evidence of compliance with one of the following:

[5] Combustion analysis is necessary when setting up an oil burner. Additionally, new oil-fired equipment no longer standardizes the pump pressure at 100 psig. Hence, incorrect pump pressure may result in an incorrect input rate for the equipment.

a) CATEGORY I vent system sized per OEM instructions and the National Fuel Gas Code (NFGC, NFPA 54)
b) CATEGORY I vent system sized per OEM instructions and the International Fuel Gas Code (IFGC)
c) CATEGORY II, III and IV vent system sized per OEM instructions
d) CATEGORY II, III and IV vent system sized per required local code

4.5.2 ACCEPTABLE PROCEDURES

The contractor shall use one or both of the following acceptable procedures for fulfilling the design criteria:

a) Comparison of the actual installation to appropriate fuel gas venting tables for Category I vent systems
b) Comparison of the actual installation to appropriate OEM instructions, for Category II, III and IV vent systems

4.5.3 ACCEPTABLE DOCUMENTATION

a) Documented field data recorded on start-up sheet
b) Documented field data recorded on service records
c) Written job documentation or checklist in job file

4.6 SYSTEM CONTROLS

The contractor shall ensure proper selection and functioning of system operational and safety controls.

4.6.1 REQUIREMENTS

The contractor shall provide evidence of the following:

a) Operating controls and safety controls are compatible with the system type and application, and the selected controls are consistent with OEM recommendations and industry practices, and
b) Operating controls and safety controls lead to proper sequencing of equipment functions, with all controls and safeties functioning per OEM or customer design specifications

NOTE: Examples of operating controls include: thermostats, humidistats, economizer controls, etc. Examples of safety controls include: temperature limit switch, airflow switch, condensate overflow switch, furnace limit switch, boiler limit switch, etc.

4.6.2 ACCEPTABLE PROCEDURES

The contractor shall use the following acceptable procedures for fulfilling the desired design criteria:

a) Confirmation of the control/safety selections made
b) Supporting OEM literature related to the selections made
c) Verification of correct cycling/operational sequences of controls and safety devices/systems per OEM specifications

4.6.3 ACCEPTABLE DOCUMENTATION

a) Documents showing that controls/safeties selections are in compliance with OEM specifications
b) Written job documentation or checklist in job file indicating that controls/safeties function properly

5.0 DUCT DISTRIBUTION ASPECTS

This section focuses on duct-related elements of the installed HVAC system.

5.1 DUCT LEAKAGE

The contractor shall ensure the ducts are sealed and that air leakage (CFM) is minimized.

5.1.1 REQUIREMENTS

The contractor shall provide evidence of meeting the following:

a) For NEW CONSTRUCTION, test using any one of the four options:
   i. Ducts located inside the thermal envelope have no more than 10% total duct leakage (airflow CFM), or iv.
   ii. Ducts located outside the thermal envelope have no more than 6% total duct leakage (airflow CFM), or iv.
   iii. EnergyStar™ Qualified Homes specification requiring that ducts must be sealed and tested to be less than 4 CFM leakage to outdoors per 100 square feet of conditioned floor area, or iv.
   iv. Per local code or authority having jurisdiction if they meet or exceed the requirements of a)i., a)ii., or a)iii.

b) For EXISTING CONSTRUCTION, test using any one of the three options:
   i. No more than 20% total duct leakage (airflow CFM) or iii.
   ii. 50% improvement on existing leakage rate or until i. is achieved or iii.
   iii. Per local code or authority having jurisdiction if they meet or exceed the requirements of b)i. or b)ii.

Notes: The total duct leakage requirement pertains to the percentage of CFM leakage as compared to the overall air handling fan flow (see §4.1) operating at design conditions. The airflow leakage shall be based on the higher design airflow requirement (i.e., the higher of the winter heating airflow or of the summer cooling airflow).

TOTAL duct leakage = SUPPLY duct leakage + RETURN duct leakage.

5.1.2 ACCEPTABLE PROCEDURES

The contractor shall test using one or more of the following acceptable procedures for fulfilling the desired criteria:

a) Duct pressurization tests[6]
b) For COMMERCIAL BUILDINGS: Total room supply CFMs and return CFMs compared with blower capability (e.g., flow hood method)
c) Blower door subtraction method[7]
d) A hybrid duct pressurization test / blower door subtraction[8]

---

[6] Duct leakage is measured using a duct pressurization test through a calibrated fan or orifice. Duct registers are sealed, a fan is attached to one opening, the ducts are pressurized to match the system operating pressures, and the amount of air flowing through the fan is quantified. A commonly known system is Duct Blaster®; there are several others as well.

[7] A calibrated fan measures whole-building leakage, then the duct grilles are sealed and the house re-measured. The difference is the amount of leakage attributable to the duct system.

5.1.3 ACCEPTABLE DOCUMENTATION

a) Documented field data recorded on start up sheet
b) Documented field data recorded on service records
c) Written job documentation or checklist in job file
d) Signed documentation from the customer that duct system repair/replacement was refused

5.2 AIRFLOW BALANCE

The contractor shall ensure room volumetric airflow CFMs meet the design/application requirements.

5.2.1. REQUIREMENTS

The contractor shall provide evidence that:

a) For NEW CONSTRUCTION or addition of new ducts to an existing structure (with bedroom doors closed) –
   For Residential Buildings: The individual room airflows are within the greater of ± 20%, or 25 CFM of the design/application requirements for the supply and return ducts.
   For Commercial Buildings: The individual room airflows are within the greater of ± 10%, or 25 CFM of the design/application requirements for the supply and return ducts.
b) For EXISTING CONSTRUCTION without contractor modification of existing ductwork –
   No ACCA requirements apply.
c) For NEW OR EXISTING CONSTRUCTION the airflow balance is per local code or authority having jurisdiction if such meet or exceed the requirements of 5.2.1.a or 5.2.1.b.

5.2.2 ACCEPTABLE PROCEDURES

The contractor shall test using one or all of the following acceptable devices for fulfilling the desired criteria:

a) Flow hoods used per specifications from the flow hood manufacturer
b) Traverse with anemometer (hotwire or rotary) used per specifications from the test equipment manufacturer
c) Pitot tube and slant manometer used per procedures specified by AABC, ASHRAE, NEBB, or TABB

Note: The use of certain measurement instruments/devices that determine airflow based on velocity measurements may be acceptable if (1) grille 'free areas' can be correctly determined and (2) the instrument/device measurement tolerances are tighter than the airflow balance tolerances.

[8] A hybrid of the duct pressurization test and the blower door subtraction methods in which: (1) a pressure match is performed in the house and the ducts and the values then compared against (2) separate measurements of the airflow into the ducts.

5.2.3 ACCEPTABLE DOCUMENTATION

a) Documented field data recorded on start up sheet
b) Documented field data recorded on service records
c) Written job documentation or checklist in job file

6.0 SYSTEM DOCUMENTATION AND OWNER EDUCATION ASPECTS

This section focuses on providing owners with job documentation, operation instructions, and education to assist them in properly operating and maintaining their systems.

6.1 PROPER SYSTEM DOCUMENTATION TO THE OWNER

The contractor shall document the HVAC installation as well as the operation and maintenance to be performed.

6.1.1 REQUIREMENTS

The contractor shall provide evidence of the following (relevant to the HVAC activity undertaken and information available to the contractor):

a) Placing copies of architectural drawings, as-built drawings, survey data, equipment submittals, equipment performance information, balance reports, equipment operation sequences, maintenance and operating instructions, and equipment/contractor warranties within easy reach of the homeowner (e.g., at the air handling cabinet) or in the hands of the building owner/operator (or designated agent).
b) Recording model and serial numbers of all equipment installed and maintaining same at the contractor's place of business.

6.1.2 ACCEPTABLE PROCEDURES

The contractor shall confirm that all the listed requirements are met.

6.1.3 ACCEPTABLE DOCUMENTATION

a) Written job documentation or checklist in job file
b) Signed documentation from the customer that the listed requirements were offered/met

6.2 OWNER/OPERATOR EDUCATION

The contractor shall educate the owner and/or operator on how to both *operate* and *maintain* the installed equipment and will promote system maintenance to aid in the continuing performance of the installed equipment.

6.2.1 REQUIREMENTS

The contractor shall conduct the following:

a) Instruct customers on proper system operation of installed equipment
b) Explain to customers the maintenance requirements for the installed equipment
c) Explain to customers warranty procedures and responsibilities

d) Provide contact information for warranty, maintenance, and service requirements

6.2.2 ACCEPTABLE PROCEDURES

The contractor shall confirm that all the listed requirements are met.

6.2.3 ACCEPTABLE DOCUMENTATION

a) Written job documentation or checklist in job file
b) Signed documentation from the customer that the listed requirements were offered/met

APPENDIX 1 | ADDITIONAL ELEMENTS FOR QUALITY INSTALLATIONS

[This Appendix is not part of the standard. It is merely informative and does not contain requirements necessary for conformance to the standard.]

This list illustrates additional elements that are important for achieving quality installations. While these items are not part of the core specification, it is acknowledged that quality installations will undoubtedly include/consider these aspects as well.

NO.		ASPECTS	GUIDELINES | CONSIDERATIONS | RECOMMENDATIONS
1	MECHANICAL	Load Parameters	- Design temperatures (OUTDOOR and INDOOR) are according to ACCA Manual J®, ACCA Manual N®, ASHRAE, DOE standards, local or state code requirements, documented customer requirements OR other recognized methodology - Area of walls, windows, skylights and doors are within ± 10% of architectural plans or actual building - Selected procedure includes: orientation of windows and glass doors (summer HEAT GAIN only); infiltration-rate; duct loads; internal gains
2		Equipment Clearances	- Clearances sufficient to enable adequate servicing of the equipment and to enable proper airflow around the outdoor unit (per OEM recommendations, International Mechanical Code, local code) - To provide adequate clearances to combustibles (per OEM specifications/recommendations; National Fuel Gas Code; International Fuel Gas Code; International Mechanical Code; local code)
3		Combustion Analysis	- Carbon monoxide (CO): no more than 100ppm at steady state high fire - Oxygen (O_2): within OEM specification - Stack Temperature: within OEM specification - Draft: within OEM specification
4		Mechanical Ventilation (if necessary)	- Outdoor air, exhaust air, building pressurization all meet local code
5		Pump(s) (if applicable)	- Properly sized and selected - Head pressure and flow (GPM) consistent with IBR Guide 2000
6	PIPING	Refrigerant Circuit Integrity	- Leak-free circuit: achieved by purging with nitrogen during brazing, conducting a nitrogen pressure test, evacuating (triple) and holding to 500 microns or less - Contaminant-free circuit: including oil removal and flushing of refrigerant lines when substituting HFC or HFC blends for CFCs and HCFCs.
7		Refrigerant Piping	- Sizing/design/insulation: in accordance with OEM specifications - Materials: copper refrigerant piping must comply with either ASTM B 280 or ASTM B 88 - Assembly: Mechanical joints are not allowed on piping larger than 7/8" annealed copper; all other joints should be brazed as defined using a nonferrous filler material having a melting point above 1000°F (538°C) but lower than the melting points of the materials being joined together
8		Condensate Drain / Piping	- Sizing/design: in accordance with OEM specifications and/or local jurisdictional codes - Materials: in accordance with OEM specifications and/or local jurisdictional codes - Assembly: in accordance with OEM specifications and/or local jurisdictional codes

9		Fossil Fuel Piping	- Sizing/design / Materials / Assembly: in accordance with the current editions of the National Fuel Gas Code or the International Fuel Gas Code - Materials: in accordance with the current edition National Fuel Gas Code or in accordance with the current edition International Fuel Gas Code - Assembly: leak free - check for leakage using approved procedure identified in the current edition National Fuel Gas Code or the current edition International Fuel Gas Code - Appliance gas inlet connections are to remain sealed or capped until final gas piping is connected to the appliance.
10	DISTRIBUTION	Duct Conduction Losses/Gains	- For the installed system (at design conditions), the temperature difference between the temperature at each/any supply register and the temperature at the evaporator coil is less than 5°F and less than 15°F from the temperature of the heat exchanger or heating element.
11		External Static Pressure Capability	- The duct system should be sized to handle the required system design CFM at the rated static pressure capability of the equipment fan/blower.
12		Air Filtration	- Filters of correct size/selection for equipment application (per application requirement/OEM specification) - Filter housing is tight with gasketed access panels/doors
13		Duct Design	- Duct Supply and Duct Return are designed per ACCA Manual D®, ACCA Manual Q®, ASHRAE standards or per other acceptable engineering methods
14		Duct Construction	- Duct material selection, construction, assembly and installation are per duct material manufacturer specifications, SMACNA standards, or the authority having jurisdiction - Flexible ducts and flexible duct connectors shall meet code requirements
15		Registers, Grilles, Diffusers	- Selection (based on throw, volume, mixing, direction, location) is per ACCA Manual D®, ACCA Manual T®, SMACNA, grill / register / diffuser manufacturer specifications.
16		Rate of Airflow	- Velocity in the duct (FPM) per ACCA Manual D® or approved equal - Velocity at the grille (FPM) per recommended FPM for the selected grille
17		Noise	- DB noise levels are compliant with recommendations from the Air Movement and Control Association (AMCA)
18		Sound Reduction	- Isolation for suspended equipment, air handlers, furnaces in attics - Isolation for roof-mounted or ground-mounted equipment
19	HYDRONICS	Balancing	- Air/water balancing: per AABC, IBR Manual (GAMA), NEBB, NCI, TABB standards
20		Hydronic Heating Water/Steam Flow	- GPM or lbs/hour - per OEM specification and system requirements

APPENDIX 2 | DEFINITIONS

[This Appendix is not part of the standard. It is merely informative and does not contain requirements necessary for conformance to the standard.]

AABC: *Associated Air Balance Council*
ACCA: *Air Conditioning Contractors of America*
airflow:

duct airflow balance: *a condition that exists when the duct system has been properly designed and assembled (i.e., sizing, friction loss, balance dampers, etc.) to ensure that the correct volume of air (in CFMs) is delivered to each room or space (This term also is used to describe work associated with the measurement and adjusting of the airflow rates at various points in an air distribution system to provide correct airflow delivery to the rooms or spaces as proscribed during the design process)*

fan airflow: *the total volume of air (in CFM) that exits the fan assembly or blower unit during operation at design conditions. [Fan airflow is a function of static pressure resistance presented by the duct system and any and all appliances connected within the subject duct system. A fan motor is designed to provide optimal airflow within a specified range of acceptable total static pressures. If a fan is installed in a duct system with appliances that exceed this total static pressure threshold, the fan cannot deliver proper airflow, and the systems capacity will be reduced. Variable speed fans do not save energy when installed in duct systems that exceed total static pressure limits – they only provide more options for multi-stage equipment.]*

room airflow balance: *a condition that exists when the airflow rate (CFM) entering a room or other enclosed space equals the airflow rate leaving the room, space or equipment*

amps (ampere; A): *A unit of electric current.*
ARI: *Air-Conditioning and Refrigeration Institute*
ASHRAE: *American Society of Heating, Refrigerating, and Air-Conditioning Engineers*
blower: *see fan*
boiler: *vessel in which a liquid is heated with or without vaporization; boiling need not occur*
bonding: *(electrical ground) connection to ground potential of a metal part on an appliance or component which may become energized by an electric fault, or develop a static charge*
BTU: *British thermal unit, the amount of heat that must be added or removed to/from one pound of water to raise or lower its temperature one degree Fahrenheit*
BTUH or BTU/H: *British thermal units added or removed per hour*
built-up system: *see system*
CEE: *Consortium for Energy Efficiency*
CFM: *cubic feet per minute (ft^3)*
clearance: *clearance for maintenance or repair: the distance between the item requiring maintenance and the closest interfering surface*
combustion: *chemical process of oxidation that occurs at a rate fast enough to produce heat and usually light either as a glow or flame*
combustion analysis: *analysis of combustion as defined above*
contractor: *the person or entity responsible for performing the work and identified as such in an owner-contractor agreement*
control: *device for regulation of a system or component in a normal and safe operation, manual or automatic; if automatic, the implication is that it is responsive to changes of pressure, temperature, or other variable whose magnitude is to be regulated*
diffuser: *an outlet designed to discharge air in a spreading pattern*
DOE: *United States Department of Energy*
EPA: *United States Environmental Protection Agency*
ESP: *external static pressure*
expansion coil: *an evaporator (heat exchanger) constructed of bare or finned pipe or tubing in which direct expansion of liquid refrigerant occurs*
fan: *device for moving air by two or more blades or vanes attached to a rotating shaft*

blower fan: *multi-bladed, driven rotor enclosed so that air from an inlet is compressed to a higher discharge pressure, which depends on conformation of the blades and the shroud at a given rotational speed*

fan airflow: *see airflow / fan airflow*

furnace: ***1.*** *part of a boiler or warm air heating system in which energy is converted to heat;* ***2.*** *enclosed chamber or structure in which heat is produced, as by burning fuel, or by converting electrical energy*

GAMA: *Gas Appliance Manufacturers Association*

grille: *a covering for an opening through which air passes*

heat gain: *The instantaneous flow (BTU/H) of sensible or latent heat entering the conditioned space or passing through a structural component. (A gain may or may not be equivalent to a space load, see Load Calculation)*

heat loss: *The instantaneous flow (BTU/H) of sensible or latent heat leaving the conditioned space or passing through a structural component. (Losses are equivalent to space loads because thermal mass effects are ignored for winter heat loss calculations, see Load Calculation).*

HVAC: *heating, ventilating and air conditioning*

HVAC system: *a system that provides either collectively or individually the processes of comfort heating, ventilating, and/or air conditioning within, or associated with, a building*

HVACR: *heating, ventilating, air conditioning, and refrigeration*

IAQ: *indoor air quality*

kilowatt-hour: *Energy used in the marketing of electrical power. Units are Kilowatt (i.e., 1000 watts) per hour of usage.*

leakage:

air leakage: *the uncontrolled exchange of air between conditioned and unconditioned building spaces (or the interior and the outdoors) through unintended openings in the building envelope and/or unintended openings in duct runs through unconditioned spaces*

duct distribution leakage: *leakage of the ambient air through the cracks and openings in supply and/or return ducts or the supply and/or return-side of HVAC equipment cabinetry*

load calculation: *A systematic method of evaluation that uses mathematical models (equations, databases, defaults and protocols) to estimate heat loss, sensible and latent heat gain, heating load, humidification load, sensible and latent cooling load, and related issues like infiltration, CFM minimum ventilation rate, month-hour temperature adjustments, building construction materials, building solar orientation, etc.*

block analysis: *a load calculation approach where the total space heat loss/heat gain load imposed on equipment is determined on a space that may include more then one room or more then one zone*

room-by-room analysis: *a load calculation approach where the combined space heat loss/heat gain load imposed on equipment is determined on a room-by-room basis*

System load*: Heat loss (sensible BTU/H) or heat gain (sensible and latent BTU/H) required for engineered ventilation, air or water distribution, relevant ancillary devices (e.g., blowers, motors, pumps), reheat and humidification.*

magnehelic: *a diaphragm-type pressure differential sensor with a direct reading gauge*

manometer: *instrument for measuring head or pressure; generally, a U-tube partially filled with a liquid, usually water, mercury, or light oil, so constructed that the difference in level of the liquid legs indicates the pressure exerted on the instrument*

measurement: ***1.*** *act or result of determining the characteristics of some thing;* ***2.*** *extent, capacity, or amount ascertained by measuring;* ***3.*** *system of measures*

nameplate rating: *full-load continuous rating of a compressor, motor, or other equipment under specified conditions, as designated by the manufacturer; and usually indicated on an attached plate*

NATE: *North American Technician Excellence*

NEBB: *The National Environmental Bureau*

NEC: *National Electrical Code*

OEM: *original equipment manufacturer*

piping: ***1.*** *system of pipes for carrying fluids;* ***2.*** *pipe or tube mains for interconnecting the various parts of a refrigerating system*

pitot tube: *small bore tube inserted perpendicular to a flowing stream with its orifice facing the stream to measure total pressure*

refrigerant: ***1.*** *in a refrigerating system, the medium of heat transfer which picks up heat by evaporating at a low temperature and pressure, and gives up heat on condensing at a higher temperature and pressure;* ***2.*** *(refrigerating fluid) fluid used for heat transfer in a refrigerating system that absorbs heat at a low temperature and low pressure of the fluid and transfers heat at a higher temperature and a higher pressure of the fluid, usually involving changes of state of the fluid*

charge: ***1.*** *actual amount of refrigerant in a closed system.* ***2.*** *weight of refrigerant required for proper functioning of a closed system*

reclaim: *(as in "reclaim refrigerant") to reprocess refrigerant to new conditions, by means which may include distillation; require chemical analysis of the contaminated refrigerant to determine that appropriate process specifications are met (This term usually implies the use of processes or procedures available only at a reprocessing or manufacturing facility)*

recover: *(as in "recover refrigerant") to remove refrigerant in any condition from a system and to store it in an external container without necessarily testing or processing it in any way*

recycle: *(as in "recycle refrigerant") to clean refrigerant for reuse by oil separation and single or multiple passes through moisture absorption devices, such as filter driers with replaceable cores, this procedure is usually implemented at the field site or at a local service shop*

safety/safeties: *see control / safety control*

SMACNA: *Sheet Metal and Air Conditioning Contractors National Association*

steady state: *state of a system in which movement of matter or energy phenomena are taking place, when the various physical phenomena are independent of time*

subcool(ing): *removal of heat from a liquid when at a temperature lower than the saturation temperature corresponding to its pressure.*

superheat(ing): *extra heat in a vapor when at a temperature higher than the saturation temperature corresponding to its pressure*

system: ***1.*** *organized collection of parts united by regular interaction;* ***2.*** *a heating or refrigerating scheme or machine, usually confined to those parts in contact with a heating or refrigerating medium*

control system: *see control*

cooling system: *apparatus for lowering the temperature of a space or product to a specified temperature level*

duct system: *A network of tubular or rectangular pipes and connectors(elbow, tees, branch fitting, and boot fitting) used to more air from one point to another*

existing system: *one that has existed previously*

heating system: *one in which heat is transferred from a source of energy through a distribution network to spaces to be heated*

matched system: *The components of a split system are matched, rated, and have demonstrable certified performance through the ARI and/or GAMA databases*

multi-zone: *HVAC system capable of handling variable loads from different sections of a building simultaneously or independently*

new system: *one that has not previously been in existence*

split system: *(as in split system air conditioner) a two component system with the condensing unit installed outside, remote from the evaporator section, which is installed in a conditioned space, and uses interconnecting refrigerant lines to connect the condensing unit to the evaporator*

venting system: *A venting system is designed in accordance with OEM and code requirements to direct flue or combustion gases from a fossil fuel burning appliance to the outside atmosphere*

TABB: *Testing, Adjusting and Balancing Bureau*

thermal envelope: *elements of a structure that enclose conditioned spaces and control transmission of heat, air, and water vapor between the conditioned spaces and the exterior*

voltage: *electric potential or potential difference expressed in volts*

watts (W): *A power term that reflects the work done or enrgy generated by one ampere induced by an emf of one volt* ($P = EI = I^2R$)

zoning: ***1.*** *division of a building or group of buildings into separately controlled spaces (zones), where different environmental conditions can be maintained simultaneously;* ***2.*** *practice of dividing a building into smaller sections for control of heating and cooling (each section is selected so that one thermostat can be used to determine its requirements)*

APPENDIX 3 | CONTRACTOR MANAGEMENT DOCUMENTATION IN SUPPORT OF QI

[This Appendix is not part of the standard. It is merely informative and does not contain requirements necessary for conformance to the standard.]

It is recognized that there are certain contractor attributes and minimum business documentations necessary to enable quality HVAC installations by installing/servicing technicians. With a focus on the business side of things – as an indicator that an HVAC contractor is positioned to properly support its sales staff and HVAC technicians in providing and servicing quality systems – three core documentation areas are identified that quality-conscious contractors follow in their management activities. These are related to:

- ✓ Business Prerequisites
  - Licensing
  - Insurance
  - Refrigerant certifications
  - Code requirements
  - Hazardous materials regulations
- ✓ Business Practices
  - Adherence to industry standards and recommended practices
  - System performance and evaluation
  - Continuing education
  - Safety programs
- ✓ Customer Satisfaction
  - Survey of customer needs and building requirements
  - Interactions with customers and/or building owners
  - Complaint resolution

QC-1 BUSINESS PREREQUISITES

This area focuses on the fundamental requirements for operating a legal contracting business.

QC-1.1 LICENSING

The contractor shall possess all statutory/regulatory licenses for the business (and, if needed, each employee) as dictated by the requirements in each jurisdiction where the contractor does business.

REQUIREMENTS

The contractor shall provide evidence of all required city, county, regional and/or state licensing for all locations where the company offers its services. All such items are to be current and actively maintained.

ACCEPTABLE DOCUMENTATION

Copies of the license(s)

QC-1.2 INSURANCE

The contractor shall carry at least the statutory levels of insurances and applicable bonds required by the appropriate jurisdictions where the company offers its services.

REQUIREMENTS

The contractor shall provide copies of appropriate certificates for all jurisdictionally required insurances for:

a) Liability
b) Worker's compensation
c) Company vehicles

ACCEPTABLE DOCUMENTATION

a) Copies of the bond
b) Copies of bonding satisfaction
c) Certificates of insurance
d) Applicable certificates of bonds and insurance from subcontractors

QC-1.3 REFRIGERANT CERTIFICATIONS

All company technicians who handle refrigerants are to recover/recycle (RR) refrigerants in compliance with EPA Section 608 regulations.

REQUIREMENTS

The contractor shall provide evidence of the following:

a) Recover/Recycle equipment owned and maintained by the business
b) Evacuation equipment capable of maintaining a vacuum of at least 500 microns owned and maintained by the business
c) Ready access to required recover/recycle equipment by company technicians who handle refrigerants
d) Training of company technicians in the correct use of recover/recycle equipment
e) Training of company technicians in the correct use of evacuation equipment
f) EPA refrigerant certifications for all company technicians who recover refrigerants, recycle refrigerants, or charge refrigerants to HVAC systems
g) Company refrigerant records being kept in compliance with Section 608 EPA regulations

[NOTE: Employees who only transport refrigerant cylinders are exempted from refrigerant certification requirements.]

ACCEPTABLE DOCUMENTATION

a) Copies of EPA refrigerant certificates for company technicians
b) Written document indicating that pertinent company personnel have been trained and that recover/recycle equipment is present and meets operational requirements

QC-1.4 CODE REQUIREMENTS

All work performed by the contractor shall comply with state and local building codes, energy codes and regulations in each jurisdiction where the contractor does business.

REQUIREMENTS

The contractor is to identify which codes are applicable to its area(s) of practice, and indicate whether it is familiar with the requirements.

HVAC equipment sizing, selection, installation, servicing, and maintenance are to be performed per pertinent codes in all areas that the contractor offers its services.

ACCEPTABLE DOCUMENTATION

a) Appropriate codes/standards/tools/software that support code compliance at company workplace
b) A written document stating that the contractor has access to applicable codes, including mechanical codes, and has personally been trained on and is familiar with these codes

QC-1.5 HAZARDOUS MATERIALS REGULATIONS

The contractor shall adhere to all federal, state, and local pollution codes and regulations as related to handling of hazardous materials, and will maintain guidelines and policies for the safe and proper handling of hazardous materials and substances at the company workplace(s) and work sites, and enforce same.

[Hazardous materials are as described by the pertinent federal, state and local codes and regulations.]

REQUIREMENTS

The contractor shall provide evidence of the following:

a) Proper storage of hazardous materials and substances at the workplace
b) Proper transportation of hazardous materials and substances to and from different sites
c) Proper use of hazardous materials and substances by the company
d) Proper disposal of hazardous materials and substances by the company
e) Company procedures for treating and cleaning up discharges and accidental spills
f) Company policy for maintaining material safety data sheets (MSDS) and for sharing information with appropriate persons
g) Adherence to all company procedures and policies on safe and proper handling of hazardous materials and substances
h) Appropriate personal safety equipment for company personnel, including gloves, safety glasses, hearing protection, breathing masks, etc

ACCEPTABLE DOCUMENTATION

a) Copy of contractor storage, transportation, handling/use, and disposal procedures/policies
b) Company injury and safety protection program
c) Copies of other pertinent company procedures/policies

QC-2 BUSINESS PRACTICES

This area focuses on the manner in which a contractor supports its sales personnel and installation/service technicians to ensure that quality installations occur in the field. Contractors are not advised on how to run their business. Rather, they are to detail the business practices, procedures, and policies that ensure employees are positioned to perform quality installations.

QC-2.1 ADHERENCE TO INDUSTRY STANDARDS AND RECOMMENDED PRACTICES

The contracting business shall maintain written policies and documentation detailing that work performed by the contractor complies with recognized industry standards and recommended practices.

Equipment sizing, selection, installation, servicing, and maintenance are to be performed per pertinent codes in all locations where the contractor does business. Load calculations, duct designs, equipment sizing/selection, and installation/servicing procedures are to be done in compliance with OEM recommendations and recognized industry standards/practices.

REQUIREMENTS

The contractor shall provide evidence of the following:

a) The company policy that for relevant work undertaken, *bona fide* load calculations are performed (e.g., ACCA Manual J® [residential], ACCA Manual N® [commercial], ASHRAE Handbook, or recognized equivalents per the authority having jurisdiction)
b) The company policy that for relevant work undertaken, appropriate duct designs and duct sizing are done (e.g., engineering plans, ACCA Manual D® [residential], ACCA Manual Q® [commercial], or recognized equivalents per the authority having jurisdiction)
c) The company policy that for relevant work undertaken, proper system and equipment selections are made (e.g., engineering plans, ACCA Manual RS® and ACCA Manual S® [residential], ACCA Manual CS® [commercial], or recognized equivalents per the authority having jurisdiction)

ACCEPTABLE DOCUMENTATION

a) Copies of company procedures/policies
b) A written document stating that related work undertaken by the contractor, or third parties on behalf of the contractor, comply with the listed requirements
c) Copies of load calculations, duct design calculations, equipment sizing/selections (hard copies or electronic) in contractor's job files

QC-2.2 SYSTEM PERFORMANCE AND EVALUATION

The contracting business is to have written policies and documentation that support company technicians and/or service personnel in performing quality installations and servicing.

Prior to recommending system modifications and/or replacements, salespersons, system designers, technicians, and/or service personnel will assess the ability of the existing system to meet desired operation and/or satisfy conditioning needs within the space.

The company personnel will assess whether the sizing and design of distribution system(s) are consistent with equipment requirements and/or applicable standards.

REQUIREMENTS

The contractor shall provide evidence of the following:

a) A written company policy on assessing duct leakage and airflow balance
b) A written company policy on assessing adequacy of existing piping (e.g., gas, refrigerant, condensate, hydronic, oil)
c) A written company policy on assessing building zoning requirements
d) A written company policy supporting the assessment of the effectiveness of both the existing equipment and the proposed equipment either by analysis, or through experience with equipment of similar design from the same manufacturing time period
e) A written company policy on how quality installations are verified in the field
f) A written company policy for ensuring that appropriate instrumentation/measurement tools are in place for each service offered by the contractor
g) A listing of instrumentation/measurement tools maintained by the company and/or technicians
h) Maintain calibration or service records for all instruments and test equipment that require regular calibration or maintenance.

ACCEPTABLE DOCUMENTATION

a) Copies of company procedures/policies
b) Instrumentation listing
c) Copies of calibration certificates or service records

QC-2.3 CONTINUING EDUCATION

The contractor shall encourage and support the continuing educational development of sales, installation, service personnel, and support staff by ensuring that company sales people, technicians and support staff receive appropriate ongoing training pertinent to the QI requirements.

REQUIREMENTS

The contractor shall provide evidence of the following:

a) A minimum of 12 equivalent hours of application and technical training per year for each company salesperson
b) A minimum of 12 equivalent hours of technical training per year for each company technician, OR technician maintains certification by an HVAC industry-recognized and accepted certification program (e.g., NATE)

ACCEPTABLE DOCUMENTATION

a) College credit in HVAC courses
b) Technical training certificates from schools and/or classes attended
c) Sales training certificates from schools and/or classes attended
d) NATE certificates and NATE certification numbers
e) Copies or samples of management or other training schedules for support staff
f) School transcripts

QC-2.4 SAFETY PROGRAMS

The contractor shall ensure employees receive the appropriate type and level of safety training.

REQUIREMENTS

The contractor shall provide evidence of the following:

a) A recognized safety program for all company employees, including fleet safety
b) A minimum of 6 hours of safety training per year for each company technician
c) Company injury protection program

ACCEPTABLE DOCUMENTATION

a) Certificates/documents of participation
b) Copies or samples of pertinent safety programs/schedules
c) OSHA card (e.g., 10-hour)
d) Red Cross (e.g., CPR training and first aid kit at the job)
e) ACCA Certificate for Safety Masters Club

QC-3 CUSTOMER SATISFACTION

This area focuses on the manner in which a contractor addresses customer issues and concerns.

QC-3.1 SURVEY OF CUSTOMER NEEDS AND BUILDING REQUIREMENTS

The contractor shall have written policies that support:

- Customer interactions at the beginning of every job to identify issues with comfort, odors, temperature, humidity, noise, and IAQ.
- Interacting with the customer after the work has been completed to ascertain satisfaction with the work undertaken.
- Building inspections to document application aspects and building construction details relating to the HVAC application.

REQUIREMENTS

The contractor shall provide evidence of the following:

a) The written policy on customer interactions
b) The written policy on HVAC system and building inspections
c) The written policy on the assessment of customer satisfaction
d) The written policy that supports a customer satisfaction program that compares and tracks actual results after installation to expected results

ACCEPTABLE DOCUMENTATION

a) The written policy on customer interactions
b) The written policy on HVAC system and building inspections
c) The written policy on assessing and evaluating buildings where equipment will be installed
d) The written policy on maintaining high levels of customer satisfaction
e) Copies or samples of surveys offered to or completed for customers
f) Copies or samples of building surveys that have been conducted

QC-3.2 INTERACTIONS WITH BUILDING OWNERS

The contractor shall have a written policy that supports advising building owners of any pre-existing defects and deficiencies that may be in the comfort system and/or building, and that supports offering options to resolve the issues.

REQUIREMENTS

The contractor shall provide evidence of the following:

a) The company policy on interacting with customers regarding pre-existing defects/deficiencies in the comfort system or building
b) A method for tracking customer instructions on corrective actions to be undertaken
c) A policy on providing written advice on comfort systems and services provided by the company for its customers

ACCEPTABLE DOCUMENTATION

a) The company policy on maintaining high levels of customer satisfaction
b) A company policy on providing clear written warranties
c) Examples of written advice given to customers on pre-existing defects in the comfort system and/or building

QC-3.3 COMPLAINT RESOLUTION

The contractor shall have a written policy to promptly address deficiencies in workmanship or materials.

REQUIREMENTS

The contractor shall provide evidence of the company policy on handling complaints about its services.

ACCEPTABLE DOCUMENTATION

a) The company policy on handling complaints about its services
b) A written document stating that the company upholds the policy

APPENDIX 4 | PERTINENT HVAC BIBLIOGRAPHY & RESOURCES

[This Appendix is not part of the standard. It is merely informative and does not contain requirements necessary for conformance to the standard.]

AABC **Associated Air Balance Council (1518 K Street NW, Suite 503, Washington, DC, 20005; tel: 202/737-0202; www.aabchq.org)**

- Commissioning Guideline, 2002
- Test and Balance Procedures, 2002

ACCA **Air Conditioning Contractors of America (2800 Shirlington Road, Suite 200, Arlington, VA, 22206; tel: 703/575-4477; www.acca.org)**

Manuals and Standards

Manual CS®	Commercial Applications, Systems and Equipment, 1st ed., 1993
Manual D®	Residential Duct Systems, 1995
Manual J®	Residential Load Calculation, 8th ed., 2006
Manual N®	Commercial Load Calculation, 4th ed., 1988
Manual RS®	Comfort, Air Quality, and Efficiency by Design, 1997
Manual S®	Residential Equipment Selection, 1995
Manual T®	Air Distribution Basics for Residential and Small Commercial Buildings, 1992
Manual Q®	Low Pressure, Low Velocity Duct System Design for Commercial Applications, 1990
Residential Ext. Care	Extended Care of Residential HVAC Systems in One- and Two-Family Dwellings Less Than Three Stories, (pending ANSI review process) 200x
System Cleanliness	Standard for Restoring the Cleanliness of HVAC Systems, 200x

Other Documents

- Residential Duct Diagnostics and Repair, ACCA, 2003
- Penney, Bradford A. J. D., Woods, James E. Ph. D. and Hourahan, Glenn C., Good HVAC Practices for Residential and Commercial Buildings: A Guide for Thermal, Moisture and Contaminant Control to Enhance System Performance and customer Satisfaction. 2003

ARI **Air Conditioning and Refrigeration Institute (4100 North Fairfax Drive, Suite 200, Arlington, VA, 22203; tel: 703/524-8800; www.ari.org)**

Standards and Guidelines

Standard 210/240-2003	Unitary Air Conditioning and Air-Source Heat Pump Equipment, 2003
Standard 340/360-2004	Commercial and Industrial Unitary Air Conditioning and Heat Pump Equipment, 2004
Standard 700-2004	Specification for Fluorocarbon Refrigerants, 2004
Standard 740-98	Refrigerant Recovery/Recycling Equipment, 1998
Standard 880-98	Air Terminals, 1998
Guideline K-2005	Containers for Recovered Fluorocarbon Refrigerants, 2005
Guideline N-2002	Assignment of Refrigerant Color Containers
Guideline Q-2001	Content Recovery and Proper Recycling of Refrigerant Cylinders, 2001

Other

- ARI Product Certification directory/database: ARI certification consists of manufacturers who voluntarily participate in independent testing to ensure that their product will perform according to published claims at specified controlled testing conditions. Go to http://www.ari.org/standardscert/certprograms/directories/ for more information.
- Industry Recycling Guide (IRG-2), Handling and Reuse of Refrigerants in the US, 1994

ASHRAE **American Society of Heating, Refrigerating and Air-Conditioning Engineers (1791 Tullie Circle, NE., Atlanta, GA; tel: 404/636-8400; www.ashrae.org)**

Standards and Guidelines

Standard 15-2004	Safety Standard for Refrigeration Systems, 2004
Standard 34-2004	Designation and Safety Classifications of Refrigerants
Standard 55-2004	Thermal Environmental Conditions for Human Occupancy. 2004
Standard 62.1-2004	Ventilation for Acceptable Indoor Air Quality, 2004
Standard 62.2-2004	Ventilation for Acceptable Indoor Air Quality in Low-Rise Residential Buildings, ANSI Approved, 2004

Standard 90.1-2004	Energy Standard for Buildings Except Low-Rise Residential Buildings, 2004
Standard 90.2-2004	Energy-Efficient Design of Low-Rise Residential Buildings, 2004
Standard 126-2000	Method of Testing HVAC Air Ducts, 2000
Standard 147-2002	Reducing the Release of Halogenated Refrigerants from Refrigerating and Air-Conditioning Equipment and Systems
Standard 152-2004	Method of Test for Determining the Design and Seasonal Efficiencies of Residential Thermal Distribution Systems
Standard 180-200x	Standard Practice for Inspection and Maintenance of Commercial HVAC Systems
Standard 183-2006	Peak Cooling and Heating Load Calculations in Buildings Except Low-Rise Residential Buildings, 2006
Guideline 0-2005	The Commissioning Process, 2005
Guideline 1-1996	The HVAC Commissioning Process, 1996
Guideline 4-1993	Preparation of Operating and Maintenance Documentation for Building Systems. 1993

Other Documents

- Handbook of Fundamentals 2005
- Harriman, Lew, Geoffrey W. Brundrett, and Reinhold Kittler. Humidity Control Design Guide for Commercial and Institutional Buildings. 2001

BCA **Building Commissioning Association (1400 SW 5th Avenue, Suite 700, Portland, OR 97201; tel: 877-666-2292; www.bcxa.org)**

- John A. Heinz & Rick Casault*, The Building Commissioning Handbook, Second Edition*

CEE **Consortium for Energy Efficiency (98 North Washington St., Suite 101, Boston, MA, 02114-1918; tel: 617-589-3949; www.cee1.org)**

The CEE/ARI Verified Directory identifies a list of products (less than 65 Mbtuh) that the manufacturer represents as meeting energy performance tiers established by the Consortium for Energy Efficiency (CEE) as part of the Residential Air Conditioner and Heat Pump Initiative and the High-Efficiency Commercial Air Conditioning Initiative. These Initiatives make use of tiers to differentiate equipment on the basis of energy performance with a higher tier representing a higher level of claimed performance. Go to http://www.ceehvacdirectory.org/

GAMA **GAMA (2107 Wilson Blvd., Suite 600, Arlington, Virginia 22201; tel: 703-525-7060; www.gamanet.org)**

- The GAMA and I=B=R Efficiency Rating Certified product directories provide free, downloadable lists of equipment and ratings tested under their various certification programs. See http://mctg.phpwebhosting.com/gama/.
- Residential Hydronic Heating Installation/Design (IBR Guide),

IAPMO **International Association of Plumbing and Mechanical Officials (5001 E. Philadelphia Street, Ontario, CA, 91761; tel: 909.472.4100; www.iapmo.org)**

- Uniform Mechanical Code, 2006
- Uniform Plumbing Code, 2006

ICC **International Code Council (5203 Leesburg Pike, Suite 600, Falls Church, VA 22041; tel: 888/422-7233; www.iccsafe.org)**

- International Building Code, 2006
- International Energy Conservation Code, 2006
- International Fire Code, 2006
- International Residential Code, 2006
- International Mechanical Code, 2006
- International Fuel Gas Code, 2006 (see Chapter 4, Tables 402.4(1) - 402.4 (33)

NAIMA **North American Insulation Manufacturers Association (44 Canal Center Plaza, Suite 310, Alexandria, VA 22314; tel 703/684-0084; www.naima.org)**

- Fibrous Glass Duct Construction Manual, 1st edition, 1989.
- Fibrous Glass Duct Construction Standard, 2002
- Fibrous Glass Duct Liner Standard, 2002

NATE **North American Technician Excellence (4100 North Fairfax Drive, Suite 210, Arlington, VA, 22203; tel: 703/276-7247; www.natex.org)**

NATE offers certifications tests for service and installation technicians to highlight relevant applied knowledge. Separate 'service' and 'installation' tests are given in the following specialty categories: air conditioning, distribution, air-to-air heat pump, gas heating (air), oil heating (air), hydronics gas, hydronics oil.

NEBB **National Environmental Balancing Bureau (8575 Grovemont Circle, Gaithersburg, Maryland 20877; tel: 301-977-3698; www.nebb.org)**

- Procedural Standards for Testing, Adjusting, Balancing of Environmental Systems, 2005
- Procedural Standards for Building Systems Commissioning, 1999

NFPA **National Fire Protection Association (Batterymarch Park, Quincy, MA, 02169, tel: 617/770-300; www.nfpa.org)**

NFPA 54	National Fuel Gas Code, 2006 (see Chapter 12, Tables 12.1 - 12.33)
NFPA90a	Standard for the Installation of HVAC Systems 1999 Edition.
NFPA 90b	Standard for the Installation of Warm Air Heating and Air-Conditioning Systems, 1999 edition.

PHCC **Plumbing-Heating-Cooling Contractors-National Association (180 S. Washington Street, P.O. Box 6808, Falls Church, VA, 22046; tel: (703) 237-8100; www.phccweb.org)**

- Heating and Cooling Technical Manual
- Testing and Balancing HVAC Systems
- Variable Air Volume Systems

RSES **Refrigeration Service Engineers Society (1666 Rand Road, Des Plaines, IL, 60016-3552; tel: 847-297-6464; www.rses.org)**

Various training manuals, self-study courses, classes and CDs to enhance the professional development of practitioners within the refrigeration sector.

NFPA **National Fire Protection Association (Batterymarch Park, Quincy, MA, 02169, tel: 617/770-300; www.nfpa.org)**

- NFPA 54: National Fuel Gas Code, 2006

PECI **Portland Energy Conservation Inc. (1400 SW 5th Ave, Suite 700, Portland, OR 97201; tel: 503/248-4636; www.peci.org)**

- Model Commissioning Plan and Guide Specifications (v2.05); available for download
- Operation and Maintenance Service Contracts: Guidelines for Obtaining Best-Practice Contracts for Commercial Buildings, available for download.
- Tudi Hassl and Terry Sharp, Practical Guide for Commissioning Existing Buildings, 1999

SMACNA **Sheet Metal and Air Conditioning Contractors' National Association (4201 Lafayette Center Drive, Chantilly, VA, 20151; tel: 703/803-2980; www.smacna.org)**

- Building Systems Analysis & Retrofit Manual, 1995
- Fibrous Glass Duct Construction Standards, 2003
- Fire, Smoke and Radiation Damper Installation Guide for HVAC Systems, 2002
- HVAC Air Duct Leakage Test Manual, 1985
- HVAC Duct Systems Inspection Guide. 2000
- HVAC Duct Construction Standards, Metal and Flexible, 2005
- HVAC Systems Commissioning Manual. 1994, 1st ed.
- HVAC Systems – Duct Design, 1990
- HVAC Systems Testing, Adjusting & Balancing. 2002, 3rd ed.
- IAQ Guidelines for Occupied Buildings Under Construction. 1995, 1st ed.
- Rectangular Industrial Duct Construction Standards, 2004
- Round Industrial Duct Construction Standards, 1999