AIR CONDITIONING
CONTRACTORS OF AMERICA

2800 Shirlington Road
Suite 300
Arlington, VA 22206

703.575.4477
Fax 703.575.8107

www.acca.org

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HVAC Quality Installation Specification

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

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CONTRACTORS	Richard Dean (Environmental Systems Associates, Inc; Columbia MD) Ellis Guiles (TAG Mechanical Systems, Inc, Syracuse NY) Stan Johnson (Stan's Heating and Air Conditioning, Inc; Austin, TX) Skip Snyder (Snyder Company, Inc; Upper Darby, PA) Larry Taylor (Air Rite Air Conditioning; Fort Worth, TX) Eric Woerner (Airtron, Inc; Miamisburg, OH)
UTILITY	Paul Kyllo (Southern California Edison; Irwindale, CA) Buck Taylor (Roltay, Inc; Madison, CT)
OEMS	Manny Cano (Lennox Industries; Lee's Summit, MO) Daniel L. Ellis (Climate Master, Inc; Oklahoma City, OK) Gary E. Georgette (Carrier Corporation; Indianapolis, IN) Raymond Granderson (Rheem Manufacturing; Fort Smith, AR) Joe C. Leonard, Jr. (Allied Air Enterprises; Blackville, SC) Chris Mann (Water Furnace International; Fort Wayne, IN) Hung M. Pham (Emerson Climate Technologies; Sidney, OH) Bill Spohn P.E. (TruTech Tools LTD; Gibsonia, PA)
ASSOCIATIONS & OTHERS	Glenn C. Hourahan, P.E. (Air Conditioning Contractors of America; Arlington, VA) Michael Lubliner (Washington State University Energy Program; Olympia WA) Warren Lupson (Air Conditioning, Heating and Refrigeration Institute; Arlington VA) Patrick L. Murphy (North American Technician Excellence; Arlington, VA) Chris Granda (Grasteu Associates; Richmond, VT) Harvey M. Sachs, Ph. D. (American Council for an Energy-Efficient Economy; Washington, DC) Frank Stanonik (Air Conditioning, Heating and Refrigeration Institute; Arlington VA) John Taylor (Consortium for Energy Efficiency; Boston, MA) Ted Leopkey (Environmental Protection Agency; Washington, DC)

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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)

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Wes Davis (Air Conditioning Contractors of America; Arlington, VA)

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)

Sally Hamlin (US EPA, Stratospheric Protection Division; Washington. DC)

Jeff Hammond (Enertech Manufacturing, LLC; Greenville IL)

Quinn Hart, P.E. (Head Quarters Air Force Civil Engineers; Tyndall AFB, FL)

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

Scott Jones (GeoSystems LLC (A subsidiary of Research Products Corp; Maple Grove, MN)

Lawrence Johnson (U.S. Air Force; Minot, ND)

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

Joseph Kounen (Building Performance Institute; Malta, NY)

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

Xiaobing Liu, Ph.D. (Oak Ridge National laboratory; Oak Ridge, TN)

Kevin B McCray (National Ground Water Association; Westerville, OH)

Michael McLaughlin (Southland Industries; Dulles, VA)

Lisa Meline, P.E. (Meline Engineering Corporation; Sacramento, CA)

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)

Donald Prather (Air Conditioning Contractors of America; Arlington, VA)

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 Awareness

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 quality installation (QI) from their HVAC contractor. Consumers and building owners/operators who understand QI 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 QI and high performance HVAC equipment enjoy enhanced comfort, reduced energy usage, improved occupant productivity, and enhanced occupant safety.

Industry Need

There is a need to establish a raised bar to improve the core competencies of contractors to ensure that quality installations occur. This is beneficial not only as a process improvement for HVAC businesses, but, more importantly, for fulfilling the needs of building owners/operators in quality installations – comfortable, safe, energy-efficient indoor environments. This Standard provides a universally accepted definition for quality installation across a broad spectrum of the HVAC industry (e.g., manufacturers, distributors, contractors, user groups, customers, utilities, efficiency advocates, trade associations professional societies, and, governmental agencies).

Full observance of the quality installation elements may increase the initial "first 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 is written with the intent that various HVAC industry stakeholders may use the criteria in diverse manners for new construction as well as replacement applications. 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

INTRODUCTION

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

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

Design Aspects:
- Ventilation
- Building heat gain/loss load calculations
- Proper equipment capacity selection
- Geothermal heat pumps ground heat exchanger
- Matched systems

Distribution Aspects:
- Duct leakage
- Airflow balance
- Hydronic balance

Equipment Installation Aspects:
- Airflow through indoor heat exchangers
- Water flow through heat exchangers
- Refrigerant charge
- Electrical requirements
- On-rate for fuel- fired equipment
- Combustion venting system
- System controls

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

This Standard, 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 may first be necessary to perform system maintenance or to restore the equipment cleanliness and condition before functional testing and verification is undertaken. Users of this specification are encouraged to review the references in Appendix D pertaining to HVAC system maintenance and cleaning.

This Standard details a level of performance that, if satisfactorily achieved, serves as an indicator that sound industry practices were likely followed 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 A. For convenience to the user, Appendix B contains generally-accepted industry definitions for a number of terms and acronyms used within the standard. Appendix C identifies business practices that contractors may find advantageous in positioning themselves to deliver quality installations on a consistent basis in the field. Finally, Appendix D highlights other references that may aid in the design, installation, servicing, maintenance, and cleaning of HVAC systems. Program Administrators and third-party verifiers are encouraged to also review ANSI/ACCA 9 QIvp (*HVAC Quality Installation Verification Protocols*). The QIvp Standard establishes minimum requirements for verifying that residential and light commercial HVAC systems meet the requirements of this QI Standard.

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<u>Appendices</u>

1.0 PURPOSE

This standard details the nationally recognized minimum criteria for the proper installation of HVAC systems in residential and commercial applications.

2.0 SCOPE

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

2.1 EQUIPMENT TYPES

2.1.1 Unitary air conditioners, air-source/water-source heat pumps, and geothermal heat pumps,

2.1.2 Furnaces (gas-fired, oil-fired, electric, and other)

2.1.3 Boilers (gas-fired, oil-fired, electric, and other).

EXCEPTIONS:
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 <u>Heating Systems / Components – Single Zone and Multizone</u>

a) Heating-only equipment and heat pumps including air-source, water-source, and geothermal 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 <u>Cooling Systems / Components – Single Zone and Multizone</u>

a) Cooling-only equipment and heat pumps including air-source, water-source, and geothermal 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 DESIGN ASPECTS

This section focuses on the upfront design procedures/tasks[1] undertaken before the equipment is actually installed.

3.1 VENTILATION

The contractor shall ensure that ventilation calculations are performed for every HVAC system installation/replacement.

3.1.1 REQUIREMENTS

The contractor shall ensure:

Building ventilation requirements (outside air, exhaust air and building pressurization) are performed to recognized standards, codes, or requirements.[2]

3.1.2 ACCEPTABLE PROCEDURES

The contractor shall follow an appropriate methodology to perform building ventilation calculations.

3.1.3 ACCEPTABLE DOCUMENTATION

The contractor shall include documentation in the installation file indicating that the ventilation calculations were addressed.[3]

3.2 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.

3.2.1 REQUIREMENTS

The contractor shall ensure:

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

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1 Informative Note: During the HVAC system design process, duct sizing calculations need to meet subsequent QI requirements:
– §4.1 & §4.2 Airflow & water flow Across Indoor Heat Exchangers
– §5.2 Airflow Balance

2 Mechanical ventilation connected to the HVAC system shall not allow the entering mixed-air temperature to be outside the temperature and humidity limits of the OEM heating and air conditioning equipment requirements.

3 The ventilation load is to be included in the overall heat gain/loss load calculations (§3.2)

NOTE 1. EXISTING BUILDING EXCEPTION:
Building heat gain / loss load calculations are not required if the original load calculations are on hand and accurately reflect the building's current construction and use.

NOTE 2. LOAD CALCULATIONS:
Room-by-room load calculations may be undertaken if so chosen by the contractor.

3.2.2 ACCEPTABLE PROCEDURES

The contractor shall perform one 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)
or
b) Confirm that the calculations were performed by a qualified third party.

3.2.3 ACCEPTABLE DOCUMENTATION

The contractor shall provide evidence of the following:

a) Load calculation worksheets included in the installation file
or
b) Appropriate documentation in the installation file.

3.3 PROPER EQUIPMENT CAPACITY SELECTION

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

3.3.1 REQUIREMENTS

The contractor shall ensure:

a) For CENTRAL AIR CONDITIONERS and HEAT PUMPS - the selected equipment will satisfy the building's load requirements at design conditions
   i. OEM product data demonstrates that latent requirements are addressed,[4]
   and
   ii. Total equipment capacity is between:
      - 95% and 115% of total cooling requirements (for air conditioners and heat pumps)
      or
      - 95% and 125% of total cooling requirements (for heat pumps with heating dominated requirements)
      or
      - the next largest nominal piece of equipment, per OEM increment,[5] that is available for either to satisfy the latent and sensible requirements.

[4] It is acceptable to include supplemental dehumidification equipment with the HVAC system to meet excess latent loads.

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
   ii. HEATING BOILERS - equipment capacity between 100% and 115% of calculated system load, OR the next largest nominal piece of equipment that is available

3.3.2 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, OEM equipment selection programs, 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.

3.3.3 ACCEPTABLE DOCUMENTATION

The contractor shall provide evidence of the following:

a) Equipment performance information in the installation file
   and
b) Written job documentation or checklist in installation file

3.4 GEOTHERMAL HEAT PUMP GROUND HEAT EXCHANGER

The contractor shall observe industry design practices for the proper design of the exterior ground heat exchanger.

3.4.1 REQUIREMENTS

The contractor shall ensure:

Ground heat exchangers are designed to satisfy the HEATING AND COOLING load requirements of the building.

i. The ground interface heat exchanger fluid[6] temperatures [extremes] and flow rates used as the basis for design equipment capacity are within the range specified in OEM guidelines
   and
ii. The ground heat exchange design methodology incorporates:
   - building loads and total installed equipment capacity
   - ground heat exchanger type, materials, and geometry
   - soil thermal characteristics
   - climatic characteristics of the project location

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5 For *Residential Applications*: Single-speed systems generally have nominal size increments of ½ ton. Multi-speed or multi-stage equipment may have nominal size increments of one ton. For *Commercial Applications*: The nominal size increases can be 1 – 5 tons.

6 Fluids may be water-or antifreeze solution for closed loop ground heat exchangers - or refrigerants in DX based ground heat exchangers. Verify fluid is allowed by local ground water authority or administrative authority.

3.4.2 ACCEPTABLE PROCEDURES

The contractor shall follow OEM guidance, recognized industry practices (ASHRAE, IGSHPA, NGWA), or procedures approved by the authority having jurisdiction.

3.4.3 ACCEPTABLE DOCUMENTATION

The contractor shall include documentation in the installation file indicating that the ground heat exchanger design objectives were met using OEM, IGSHPA, NGWA ASHRAE, or procedures approved by authority having jurisdiction.

3.5 MATCHED SYSTEMS

The contractor shall ensure that all heating and cooling equipment are properly matched systems as identified by industry-recognized certification programs.

3.5.1 REQUIREMENTS

The contractor shall ensure:

Matched systems in accordance with one of the following:

a) AHRI Product Certification directory/database (www.ahridirectory.org)
or
b) CEE directory of AHRI-verified equipment (www.ceehvacdirectory.org)
or
c) Selection of indoor coil and air handler to correctly match OEM performance data for matching indoor and outdoor components that meet §3.3 and §3.4 requirements.

3.5.2 ACCEPTABLE PROCEDURES

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

a) Confirmation of system matching compliance as compared to a recognized product certification database
or
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)

3.5.3 ACCEPTABLE DOCUMENTATION

The contractor shall provide evidence of the following:

a) Copy of the AHRI *or* CEE-AHRI record/certificate, with appropriate reference number indicated for the matched system, in the installation file.
or
b) Copy of OEM-provided catalog data, indicating acceptable combination selection and performance data, in the installation file.

4.0 EQUIPMENT INSTALLATION ASPECTS

This section focuses on the HVAC system installation.

4.1 AIRFLOW THROUGH INDOOR HEAT EXCHANGERS

> The contractor shall verify that the airflow through the indoor blower unit, (e.g. furnace, fan coil, air handler) is within acceptable CFM ranges.

4.1.1 REQUIREMENTS

The contractor shall ensure:

Measured airflow[7] through the indoor heat exchanger (with all accessories and system components in place):

a) For cooling (e.g., refrigerant, water) and heat pump applications
   i. Airflow through the unit, at fan design airflow under steady state condition is within 15% of the airflow required per the system design,
   and
   ii. Airflow through the unit is within the CFM range listed in the OEM product data,[8]
   and
   iii. Measured external static pressure (ESP)[9] is:
      1) Within OEM-specified acceptable range,
      and
      2) Not more than 25% or 0.10 iwc (which ever is greater) over the calculated ESP used to design the duct system. [Exception for existing buildings: measured ESP is not required for change-out applications if there has been no modification to the pre-existing ductwork.]

b) For gas-fired, oil-fired, or electric heat exchanger applications
   i. Airflow, through the heat exchanger, at the selected fan speed under steady-state conditions is within 15% of the airflow required per the system design,
   and
   ii. Airflow through the indoor heat exchanger is within the CFM range listed in the OEM product data,
   and
   iii. Heat exchanger airflow requirements shall be considered separately from any combined and attached cooling coils sharing the same distribution duct system,
   and
   iv. Measured external static pressure (ESP) is:
      1) Within OEM-specified acceptable range,

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7 When verifying design airflow at design fan speed, there is little distinction between a split capacitor fan motor (PSC) or a variable speed fan motor (e.g., brushless DC, electronically commutated motor; ECM). See "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.

8 Airflow across the coil is typically between 350 to 450 CFM per ton. Adjustments may be needed between dry and wet coils.

9 Static pressure measurements require clean components: filters, coils, and fans for each indoor unit type

and

2) Not more than 25% or 0.10 iwc (which ever is greater) over the calculated ESP used to design the duct system. [Exception for existing buildings: measured ESP is not required for change-out applications if there has been no modification to the pre-existing ductwork.]

4.1.2 ACCEPTABLE PROCEDURES

The contractor shall use one of the following acceptable methods for fulfilling the design criteria:

a) OEM CFM/static pressure drop coil table method using a manometer and probe to determine the static pressure drop across a cooling coil, furnace, or fan coil unit and compare with OEM values
or
b) Traversing using a manometer and probe, or an anemometer (e.g., hot wire, rotary style) or other methods per ACCA, AABC, ASHRAE, ASTM, NEBB, SMACNA, or TABB procedures
or
c) Flow grid measurement method
or
d) Pressure matching method[10]
or
e) The temperature rise method (for heating only: gas or oil furnace, electric resistance heat, geothermal and water source heat pump) to verify proper airflow through the heat exchanger or heater elements. [NOTE: It is not acceptable to use the temperature rise method to determine cooling airflow over the indoor coil.]

4.1.3 ACCEPTABLE DOCUMENTATION

The contractor shall provide evidence of the following:

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

4.2 WATER FLOW THROUGH INDOOR HEAT EXCHANGERS

The contractor shall verify that the water flow[11] through the refrigerant-to-water, water-to-water, or water-to-air heat exchanger are within acceptable ranges.

4.2.1 REQUIREMENTS

The contractor shall ensure:

[10] Use of a calibrated fan to match the supply plenum pressure and measurement of the system airflow through the active fan. Note: Methods for use with brushless DC or ECM blowers in accordance with the motor or OEM instructions.

[11] Water may be treated or contain antifreeze.

a) Water flow through the heat exchanger is within 10% of the water flow required per the system design.
and
b) Water flow through the heat exchanger is within the range listed in the OEM product data.

4.2.2 ACCEPTABLE PROCEDURES

The contractor shall test using one of the following acceptable methods for fulfilling the desired criteria:

a) The water pressure drop method
or
b) The water temperature change method
or
c) Any method approved and specifically stated by the OEM that can be used to determine the water flow rate

4.2.3 ACCEPTABLE DOCUMENTATION

The contractor shall provide evidence of the following:

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

4.3 REFRIGERANT CHARGE

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

4.3.1 REQUIREMENTS

The contractor shall ensure:

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

NOTE 1. FLOW THROUGH THE HEAT EXCHANGER:
Proper airflows §4.1 and/or water flows §4.2 through the heat exchanger must be within acceptable OEM tolerances before the refrigerant charge can be measured and/or adjusted.

NOTE 2. MEASUREMENT PARAMETERS:
The system must be within the OEM's temperature parameters at steady state conditions before system charge measurements are undertaken.

NOTE 3. REFRIGERANT CHARGE TOLERANCES:
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.

4.3.2 ACCEPTABLE PROCEDURES

The contractor shall use one of the following acceptable procedures for completing the desired measurements after confirmation of required airflow (per §4.1) and/or water flow (per §4.2) through the indoor coil:

a) Superheat test done under outdoor ambient conditions, as specified by the OEM instructions (typically, 55°F drybulb temperature or higher)
or
b) Subcooling test done under outdoor ambient conditions, as specified by the OEM instructions (typically, 60°F or higher)
or
c) Any method approved and specifically documented by the OEM that will ensure proper refrigerant charging of the system.

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

4.3.3 ACCEPTABLE DOCUMENTATION

The contractor shall provide evidence of the following:

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

4.4 ELECTRICAL REQUIREMENTS

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

4.4.1 REQUIREMENTS

The contractor shall ensure:

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
and
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
and
c) LINE and LOW-VOLTAGE wiring sizes per NEC (National Electric Code) or equivalent
and
d) GROUNDING/BONDING per NEC or equivalent

4.4.2 ACCEPTABLE PROCEDURES

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

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

4.4.3 ACCEPTABLE DOCUMENTATION

The contractor shall provide evidence of the following:

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

4.5 ON-RATE FOR FUEL-FIRED EQUIPMENT

> The contractor shall ensure the equipment combustion is "on-rate", for gas-fired or oil-fired equipment, and is at the equipment nameplate value.

4.5.1 REQUIREMENTS

The contractor shall ensure:

a) Gas-Fired Equipment:

The contractor shall ensure:
i. Firing rate within ± 5% of nameplate input for gas equipment (or per OEM specifications)
and
ii. Temperature rise within the nameplate limits

b) Oil-Fired Equipment:

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

4.5.2 ACCEPTABLE PROCEDURES

a) Gas-Fired Equipment:

The contractor shall test using one 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.
or
iii. Perform a combustion analysis per OEM installation or gas burner instructions.

b) Oil-Fired Equipment:

The contractor shall fulfill the following criteria:
i. Verify nozzle or alternate input nozzle per OEM installation and oil burner instructions.
and
ii. Verify oil pump pressure with a dial or electronic gauge designed for oil pressure measurement
and
iii. Measure the temperature rise at steady-state conditions (with airflow first verified by §4.1) –furnaces only.
or
iv. Perform a combustion analysis per OEM installation and oil burner instructions.[12]

4.5.3 ACCEPTABLE DOCUMENTATION

The contractor shall provide evidence of the following:

a) Documented field data recorded on start-up sheet
and
b) Written job documentation or checklist in the installation file

4.6 COMBUSTION VENTING SYSTEM

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

4.6.1 REQUIREMENTS

The contractor shall install the vent system to:

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

[12] 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.

4.6.2 ACCEPTABLE PROCEDURES

The contractor shall use one of the following acceptable procedures for fulfilling the installation criteria:

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

4.6.3 ACCEPTABLE DOCUMENTATION

The contractor shall provide evidence of the following:

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

4.7 SYSTEM CONTROLS

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

4.7.1 REQUIREMENTS

The contractor shall ensure:

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 OPERATING CONTROLS:
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.

4.7.2 ACCEPTABLE PROCEDURES

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

a) Confirmation of the control/safety selections made
and
b) Supporting OEM literature related to the selections made
and

c) Verification of correct cycling/operational sequences of controls and safety devices/systems per system design and OEM specifications

4.7.3 ACCEPTABLE DOCUMENTATION

The contractor shall provide evidence of the following:

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

5.0 DISTRIBUTION ASPECTS

This section focuses on heating and cooling delivery 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 ensure:

a) For NEW CONSTRUCTION, test using any one of the three options:
   i. Ducts located inside the thermal envelope have no more than 10% total duct leakage (airflow in CFM: duct pressure 25 Pascals),
   or
   ii. Ducts located outside the thermal envelope have no more than 6% total duct leakage (airflow in CFM: duct pressure 25 Pascals),
   or
   iii. Per local code or authority having jurisdiction

b) For EXISTING CONSTRUCTION, test using any one of the three options:
   i. No more than 20% total duct leakage (airflow in CFM: duct pressure 25 Pascals)
   or
   ii. 50% improvement on existing leakage rate or until 5.1.1.b.i. is achieved
   or
   iii. Per local code or authority having jurisdiction

NOTE 1. DUCT LEAKAGE:
The total duct leakage allowable 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 allowable shall be based on the higher of the winter heating airflow or of the summer cooling airflow.
TOTAL duct leakage = SUPPLY duct leakage + RETURN duct leakage.

NOTE 2. DUCT SEALING:
For duct sealing, all duct sealing materials shall be rated to UL 181A or UL 181B specifications and shall be used in strict accordance with OEM instructions.

5.1.2 ACCEPTABLE PROCEDURES

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

a) Duct pressurization tests[13] at 25 Pascal
   or
b) FOR COMMERCIAL BUILDINGS, airflow comparison method[14]
   or

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[13] 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, and the amount of air flowing through the fan is quantified. A commonly known system is Duct Blaster®; there are several others as well.

[14] Total room supply CFMs and return CFMs compared with blower capability (e.g., airflow measuring device method: Commonly referred to as Flow Hood™, Shortridge or Balometer™, Alnor), as per procedures specified by ACCA, AABC, ASHRAE, NEBB and TABB.

c) Hybrid blower door/airflow measuring device subtraction[15]
or
d) Duct pressurization test at referenced pressure standard by authority having jurisdiction.

5.1.3 ACCEPTABLE DOCUMENTATION

The contractor shall provide evidence of the following:

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

5.2 AIRFLOW BALANCE

The contractor shall ensure room airflows meet the design/application requirements.

5.2.1. REQUIREMENTS

The contractor shall ensure:

a) For NEW CONSTRUCTION or addition of new ducts to an existing structure (with interior doors closed AND open) –
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.
or
b) For EXISTING CONSTRUCTION without contractor modification of existing ductwork: No additional ACCA QI requirements apply.
or
c) For NEW OR EXISTING CONSTRUCTION the airflow balance is per local code or authority having jurisdiction.

NOTE ON AIRFLOW THROUGH INDOOR HEAT EXCHANGERS:
Per §4.1, airflow through the heat exchanger must be within the OEM's specified range for all furnace, fan coil, and air handler applications.

5.2.2 ACCEPTABLE PROCEDURES

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

a) Airflow measuring device (AMD)[16] used per specifications from the AMD manufacturer
or

15 A calibrated fan measures whole-building positive or negative pressure on the building, then duct leakage is measured by placing an airflow capture hood over the grilles and registers.
16 Commonly referred to as Shortridge flow hood™ or Alnor Balometer™.

b) Duct traverse with Pitot tube and manometer per procedures specified by ACCA, AABC, ASHRAE, NEBB, SMACNA or TABB
or
c) Measure the average airflow using an anemometer (hotwire or rotary) per specifications from the test equipment manufacturer.[17]

5.2.3 ACCEPTABLE DOCUMENTATION

The contractor shall provide evidence of the following:

a) Documented field data recorded on start up sheet or test and balance form
or
b) Documented field data recorded on service records
and
c) Written job documentation or checklist in the installation file

5.3 HYDRONIC BALANCE

The contractor shall ensure water flows meet the design/application requirements.

5.3.1. REQUIREMENTS

The contractor shall ensure:

a) For NEW CONSTRUCTION, or addition of new piping to an existing HVAC system, the water flow to individual room or zone heat exchangers are within $\pm$ 10% of the design/application GPM requirements.
or
b) For EXISTING CONSTRUCTION without contractor modification of existing piping: No additional ACCA QI requirements apply.
or
c) For NEW OR EXISTING CONSTRUCTION the room/zone hydronic balance is per local code or authority having jurisdiction.

NOTE ON WATER FLOW THROUGH HEAT EXCHANGER:
Per §4.2, water flow through the heat exchanger must be within the OEM's specified range for all boilers, and water-to-water geothermal heat pump applications.

5.3.2 ACCEPTABLE PROCEDURES

The contractor shall use one of the following acceptable tests for fulfilling the desired criteria:

a) Manometer and probe used per instructions from the instrument manufacturer.
or
b) Ultrasonic/Doppler flow meter used per instructions from the instrument manufacturer.

[17] The use of anemometers is acceptable if (1) grille "free areas" are known and if (2) the measurement tolerances for the instrument/device being used are considerable tighter than the airflow balance tolerances. The grill "free area" is commonly known as the area-K (or Ak) and the values are provided by the grille/diffuser OEM.

or

c) Pressure gauge used per instructions from the instrument manufacturer

or

d) Procedures specified by OEM

5.3.3 ACCEPTABLE DOCUMENTATION

The contractor shall provide evidence of the following:

a) A copy of documented field data recorded on start up sheet or test and balance form

or

b) Documented field data recorded on service records

and

c) Written job documentation or checklist in the installation 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 provide records pertaining to the HVAC system installation as well as the operation and maintenance to be performed.

6.1.1 REQUIREMENTS

The contractor shall ensure:

a) An installation file of required and relevant information is created and provided to the homeowner or the building owner/operator (or designated agent).
   i) Required documentation: Information detailed in the *Acceptable Documentation*[18] of each applicable section.
   and
   ii) Relevant documentation: additional information applicable to the HVAC activity undertaken.[19]
   and
b) Copies of documents from §6.1.1.a and a record of the model and serial numbers of all equipment installed are maintained 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

The contractor shall provide evidence of the following:

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

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18 Examples of required acceptable documentation include: ventilation calculations (§3.1), load calculations (§3.2), OEM performance data (§3.3), AHRI certificates (§3.5), records of measurements (§4.1, §4.2, §4.3, §4.4, §4.5), documented field data (§4.6), written documentation of proper operation sequences (§4.7), duct leakage tests (§5.1), test and balance reports (§5.2, §5.3), and customer education (§6.2).

19 Examples of relevant documentation include: permits, as-built drawings (including the type, size, and location of all underground heat geothermal heat exchange piping), survey data, equipment submittals, maintenance and operating instructions, and equipment/contractor warranties.

6.2 OWNER/OPERATOR EDUCATION

The contractor shall inform the customer 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 ensure:

a) Customers are instructed on system operation of installed equipment
and
b) Customers are instructed on the maintenance requirements for the installed equipment
and
c) Customers are instructed on warranty procedures and responsibilities
and
d) Customers are provided with 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

The contractor shall provide evidence of the following:

a) Written job documentation or checklist in the installation file
or
b) Signed documentation from the customer that the listed requirements were offered/met; including the date and names of the trainer and the building owner/operator (or designated agent) receiving the instruction.

APPENDIX A | 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 elements that are important for achieving quality installations. While some of 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	MECHANICAL	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 Association of Plumbing and Mechanical officials; International Fuel Gas Code; International Mechanical Code; local code)
3	MECHANICAL	Combustion Analysis	- Carbon monoxide (CO): within OEM specifications - Oxygen (O_2): within OEM specifications - Stack Temperature: within OEM specifications - Draft: within OEM specifications
4	MECHANICAL	Mechanical Ventilation	- Outdoor air, exhaust air, building pressurization in accordance with ASHRAE Standard 62.1 (for commercial buildings) or ASHRAE Standard 62.2 (for residential buildings) and shall meet local code
5	MECHANICAL	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	PIPING	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	PIPING	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 - 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 specifications) - 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	- Decibel (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	Geothermal	- Sizing and design, piping, materials and joining methods, purging, air elimination, and charging (non-refrigerant), instructions for geothermal heat exchangers must be done in accordance with OEM instructions and applicable ACCA, ASHRAE, AHRI, IGSHPA, and NGWA standards and guidelines.
20		Hydronic Heating Water/Steam Flow	- GPM or lbs/hour - per OEM specifications and system requirements

APPENDIX B | 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

AHRI: Air-Conditioning Heating, and Refrigeration Institute
amps (ampere; A): A unit of electric current.
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
duct modification: A change in the air distribution network that includes additions or deletions of duct runs or changes register/grille location(s). This does not include transitions at the air handler supply and return. Additionally, simple repairing or replacing damaged duct runs with like-size ducts are excluded from this definition.
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

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

Geothermal Heat Pump System: A geothermal heat pump system rejects heat to (in cooling mode) or extracts heat from (in heating mode) various ground resources, including the shallow surface of the Earth, ground water, surface water, etc. A geothermal heat pump system consists of the following three major components, a water source heat pump unit operable over an extended range of entering fluid temperatures, a ground heat exchanger, and a circulation system. Additionally, for ground water heat pump systems that do not use the direct expansion type of ground heat exchanger, a pump or pumps are usually needed to circulate the heat transfer medium (water or aqueous antifreeze solution) through the geothermal heat pump and the ground heat exchanger.

Geothermal Heat Pump:** A geothermal heat pump uses the thermal energy of the ground or groundwater (or otherwise wasted resources) to provide residential or commercial space conditioning and/or domestic water heating. A geothermal heat pump normally consists of one or more factory-made assemblies that include indoor conditioning and/or domestic water heat exchanger(s), compressors, and a ground-side heat exchanger. A geothermal heat pump may provide space heating, space cooling, domestic water heating, or a combination of these functions and may also include the functions of liquid circulation, thermal storage, air circulation, air cleaning, dehumidifying or humidifying.

Ground Heat Exchanger: The method by which heat is exchanged with the ground, groundwater, or surface water. Geothermal heat pumps may use any form of ground heat exchange, which includes horizontal, vertical, or submerged surface water closed loops; open loops using ground water, reclaimed water, or surface water; or direct refrigerant-to-ground or refrigerant-to-water heat exchange.

Closed Loop: A ground heat exchange method in which the heat transfer fluid is permanently contained in a closed piping system.

Open Loop: A ground heat exchange method in which the heat transfer fluid is part of a larger environment. The most common open loop systems use ground water, reclaimed water, or surface water as the heat transfer medium.

GPM: Gallons per minute

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).

heat pump*: thermodynamic heating/refrigerating system to transfer heat in either direction. By receiving the flow of air or other fluid, a heat pump is used to cool or heat.

cooling and heating heat pump*: system designed to utilize alternately or simultaneously the heat extracted at a low temperature and the heat rejected at a higher temperature for cooling and heating functions, respectively.

heating heat pump*: refrigerating system designed primarily to utilize the heat rejection from the system for a desired heating function.

HIA: Hydronics Industry Alliance

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

IBR or I=B=R: AHRI training program for fossil fuel and hydronic appliances.

IFGC: International Fuel Gas Code
IGSHPA: The International Ground Source Heat Pump Association
installation file: The information left with or attached to the installed equipment. Owner's information.
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
>
> **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 than one room or more than 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; traditionally, a U-tube partially filled with a liquid, usually water, mercury, or manometer gage 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 Balancing Bureau
NEC: National Electrical Code
NFGC: National Fuel Gas Code
OEM: original equipment manufacturer
on-rate (also known as fuel flow rate): refers to the volume of fuel flowing into the combustion process at steady-state operation. Once the measured flow is corrected for temperature and altitude, the on-rate (for gas, rated in Btu/ft^3; for oil, rated in Btu/gal) can be established utilizing a fuel's heat content in Btu.
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: HVAC system operating in equilibrium (generally operating constantly for over 10 minutes) A system operating in a stable condition over time; where the change in one direction is balanced by change in another

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

geothermal heat pump system: see geothermal heat pump

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 certified performance through the AHRI and/or CEE 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

total load: Sensible plus latent requirements in BTU/hr.

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

unitary air conditioner*: one or more factory-made assemblies which normally may include an evaporator or cooling coil, a compressor and condenser combination, and may include a heating function.

voltage: electric potential or potential difference expressed in volts

watts (W)*: A power term that reflects the work done or energy 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)

* Definition adapted from ASHRAE Terminology of Heating, Ventilation Air Conditioning & Refrigeration Second Edition 1991.

** Definition adapted from Energy Star Program Requirements for Geothermal Heat Pumps Partner Commitments Version 3 Definitions section.

APPENDIX C | 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.aabc.com)**

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

ACCA **Air Conditioning Contractors of America (2800 Shirlington Road, Suite 300, Arlington, VA, 22206; tel: 703/575-4477; www.acca.org)**

Manuals and Standards

Manual B®	Balancing and Testing of HVAC Systems, 2009
Manual CS®	Commercial Applications, Systems and Equipment, 1st ed., 1993
Manual D®	Residential Duct Systems, 2009
Manual J®	Residential Load Calculation, 8th ed., 2006
Manual N®	Commercial Load Calculation, 5th ed., 2008
Manual RS®	Comfort, Air Quality, and Efficiency by Design, 1997
Manual S®	Residential Equipment Selection, 1995
Manual SPS®	HVAC Design for Swimming Pools and Spas, 2010
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
Manual Zr®	Residential HVAC System Zoning, 201x
ACCA 4 QM - 2007	Maintenance of Residential HVAC Systems in One- and Two-Family Dwellings Less Than Three Stories, (pending ANSI review process), 2007
ACCA 6 QR - 2007	Standard for Restoring the Cleanliness of HVAC Systems, 2007
ACCA 9 QIvp - 2011	HVAC Quality Installation Verification Protocols, 2011

Other Documents

- Bob's House: Understanding the Residential HVAC Design Process, 2007
- Technician's Guide for a Quality Installation, 2010
- Residential Duct Diagnostics and Repair, 2003
- HVAC Practices for Residential and Commercial Buildings: A Guide for Thermal, Moisture and Contaminant Control to Enhance System Performance and customer Satisfaction, 2003

AHRI **Air Conditioning, Heating and Refrigeration Institute (4100 North Fairfax Drive, Suite 200, Arlington, VA, 22203; tel: 703/524-8800; www.ahrinet.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, 2002
Guideline Q-2001	Content Recovery and Proper Recycling of Refrigerant Cylinders, 2001

Other Documents

- AHRI Product Certification directory/database: AHRI 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.ahridirectory.org/ahridirectory/pages/home.aspx for more information.
- Industry Recycling Guide (IRG-2), Handling and Reuse of Refrigerants in the US, 1994
- IBR (or I=B=R) Efficiency Rating Certified product directories provide free, downloadable lists of equipment and ratings tested under their various certification programs. See http://www.ahrinet.org/Content/GAMAIBRCertification_581.aspx.
- Residential Hydronic Heating Installation/Design (IBR Guide), 2009

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 15-2007	Safety Standard for Refrigeration Systems, 2007
Standard 34-2007	Designation and Safety Classifications of Refrigerants, 2007
Standard 55-2004	Thermal Environmental Conditions for Human Occupancy, 2004
Standard 62.1-2007	Ventilation for Acceptable Indoor Air Quality, 2007
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 111-2008	Practices for Measurement, Testing, Adjusting, and Balancing of Building Heating, Ventilation, Air Conditioning and Refrigeration Systems, 2008
Standard 126-2008	Method of Testing HVAC Air Ducts, 2008
Standard 147-2002	Reducing the Release of Halogenated Refrigerants from Refrigerating and Air-Conditioning Equipment and Systems, 2002
Standard 152-2004	Method of Test for Determining the Design and Seasonal Efficiencies of Residential Thermal Distribution Systems, 2004
Standard 180-2008	Standard Practice for Inspection and Maintenance of Commercial HVAC Systems, 2008
Standard 183-2007	Peak Cooling and Heating Load Calculations in Buildings Except Low-Rise Residential Buildings, 2007
Guideline 0-2005	The Commissioning Process, 2005
Guideline 1.1-2007	The HVAC Commissioning Process, 2007
Guideline 4-2008	Preparation of Operating and Maintenance Documentation for Building Systems, 2008

Other Documents

– Handbook of Fundamentals, 2009
– Humidity Control; Harriman, Lew, Geoffrey W. Brundrett, and Reinhold Kittler
– Design Guide for Commercial and Institutional Buildings, 2001
– AHHRAE Terminology of Heating, Ventilation, Air Conditioning, & Refrigeration, 1991

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

– *The Building Commissioning Handbook*, 2nd Edition, John A. Heinz & Rick Casault

BPI **Building Performance Institute (107 Hermes Road, Suite 110 Malta, NY 12020; 1-877-274-12741400; http://www.bpi.org/**

Various standards aimed at enhancing performance development of professional building performance analysis for: Air Conditioning and Heat Pumps, Building Envelope, Manufactured Housing, and Multifamily Buildings

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

The CEE/AHRI Verified Directory identifies a list of products (less than 65 Mbtuh) that the equipment manufacturers represent 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/

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 (500 New Jersey Avenue, NW 6th Floor, Washington, DC 20001; 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)

IGSHPA **International Ground Source Heat Pump Association (374 Cordell South, Stillwater, OK 74078; tel: 405/774-5175; www.igshpa.okstate.edu)**

- Design and Installation Guide, 2009
- Residential and light Commercial Design and Installation Guide, 2003
- Closed-Loop Geothermal Systems, 2009
- Closed-Loop Geothermal Systems Slinky™ Guide, 2003
- Closed-Loop Geothermal Systems Soil and Rock Classification Field Manual, 2004
- Grouting for Vertical Geothermal Heat Pump Systems Engineering Design and Field Procedures Manual, 2000
- Closed-Loop Ground-Source Heat Pump Systems Installation Guide, 2007

NADCA **National Air Duct Cleaning Association (1518 K Street, N.W., Suite 503, Washington, D.C., 20005; tel: 202/737-2926; www.nadca.com)**

- ACR Standard, 2006 Edition: Assessment, Cleaning & Restoration of HVAC Systems

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, light commercial refrigeration. Other credentials offered: ground source heat pumps, HVAC efficiency analyst

NEBB **National Environmental Balancing Bureau (PO Box 2519, Liverpool, New York 13089; tel: 315-303-5559; 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.

NGWA **National Ground Water Association (601 Dempsey Road, Westerville, OH 43081; tel: 614/898-7791; www.ngwa.org)**

- Guidelines for Construction of Loop Wells for Vertical Closed Loop Ground Source Heat Pump Systems, 3rd Edition, 2010
- Development Methods for Water Wells, 1991
- Ground Water Hydrology for Water Well Contractors, 1982
- Guide for Using the Hydrogeologic Classification System for Logging Water Well Boreholes, 2006
- Sealing Abandoned Wells, 1994
- Basic Water Systems: A Pump and Hydraulic Training Manual, 2002

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.
- Practical Guide for Commissioning Existing Buildings, Tudi Hassl and Terry Sharp, 1999

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)**

- National Standard Plumbing Code, 2009
- Variable Air Volume Systems, 1998

RESNET **Residential Energy Services Network (P.O. Box 4561, Oceanside, CA 92052-4561; 1-800-836-7057; http://www.resnet.us/)**

- Mortgage Industry National Home Energy rating Standard, 2009
- RESNET National Standard for Home Energy Audits, 2005
- ENERGY STAR Homes Building Option Package (BOP) Standard, 2000
- RESNET Procedures for Certifying Residential Energy Efficiency Tax Credits, 2005
- Rating and Home Energy Survey Ethics and Standards of Practice, 1996
- RESNET Procedures for Verification of International Energy Conservation Code Performance Path Calculation Tools, 2004
- RESNET Standards for Qualified Contractors and Builders, 2010

RPA **Radiant Panel Association (Batterymarch Park, Quincy, MA, 02169, tel: 617/770-300; www.radiantpanelassociation.org)**

- RPA Guidelines for the Design and installation of Radiant Heating and Snow Ice Melt Systems, 2010
- Modern Hydronic Heating for Residential & light Commercial, 2003

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.

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 Edition
- IAQ Guidelines for Occupied Buildings Under Construction. 1995, 1st Edition
- Rectangular Industrial Duct Construction Standards, 2004
- Round Industrial Duct Construction Standards, 1999

UL **Underwriters Laboratories Inc. (333 Pfingsten Road, Northbrook, IL, 60062; tel: 847-272-8800; www.ul.com)**

Standard UL-181	Standard for Safety Factory-Made Air Ducts and Air Connectors, 2003
Standard UL-181A	Standard for Safety Closure Systems for Use with Rigid Air Ducts and Air Connectors, 2005
Standard UL-181B	Standard for Safety Closure Systems for Use with Flexible Air Ducts and Air Connectors, 2005

ACCA®
Air Conditioning Contractors of America
2800 Shirlington Road, Suite 300
Arlington, VA 22206
www.acca.org