



PROCEDURES FOR HVAC SYSTEM INSTALLATION Scope of Work

The goal for a HVAC system is to provide proper airflow, heating, and cooling to each room. The following pages contain more detailed information on fabrication, installation and performance testing.

California:

When "Duct Leakage Reduction Compliance Credit" is selected as a feature in California energy calculations, verification of leakage rate is required. The installer must test every home either at rough or final. At rough, without the air handler installed, maximum allowable leakage (calculated as percent of total fan flow) is 4%. At rough with the air handler installed, or at final, maximum allowable leakage is 6%. If the installer chooses to test and certifies leakage at rough, the installer must inspect the system at final. The installer must complete a CF-6R for each home.

Third party verification is also required by a HERS Rater with current certification by a California Energy Commission (CEC) approved Rater Provider. The HERS Rater must test at final using the CEC sampling protocol. Maximum allowable leakage is 6% (calculated as percent of total fan flow). The HERS Rater must inspect using the CEC protocols and the HERS Rater must complete a CF-4R for each home.

Criteria

An HVAC system should:

1. Be installed so that the static air pressure drop across the handler is within manufacturer and ConSol design specifications
2. Have sealed supply and return ductwork that will provide proper airflow, and avoid air entering the HVAC system from polluted zones (e.g., fumes from autos and stored chemicals, and attic particulates)
3. Have balanced airflows between supply and return systems to maintain neutral pressure in the home
4. Minimize duct air temperature gain or loss between the air handler and supply registers; and between return registers and the air handler
5. Be properly charged with refrigerant
6. Have proper burner operation and proper draft

Procedures (Procedures are detailed in accompanying Scope of Work.)

1. Install equipment and ducts using installation requirements and procedures from the Uniform Mechanical Code, the Air Diffusion Council, SMACNA, California Residential Energy Efficiency Standards (Title 24), and manufacturers' specifications
2. Charge the system appropriately, and verify charge with the evaporator superheat method or subcooling method (or substantially equivalent)
3. Test the system to ensure that it performs properly
 - a) does not leak substantially
 - b) proper air handler fan flow
 - c) proper supply and return air flows
 - d) proper plenum static pressures

Details for an HVAC System: Materials, Fabrication, Design, Installation, and Performance Testing

MINIMUM MATERIALS SPECIFICATIONS

The following are minimum materials specifications recommended to achieve a substantially tight installation that will last:

All Materials

- Shall have a minimum performance temperature ratings per UL181 (ducts), UL181A (closure systems for rigid fiberglass ducts), UL181B (closure systems for flexible ducts) and/or UL 181BM (mastic); Butyl-back tape may also be used to seal ducts, ductboard and metal;
- Shall have a flame spread rating of no more than 25 and a maximum smoke developed rating of 50 (ASTM E 84);

Factory-Fabricated Duct Systems

- All factory-fabricated duct systems shall include UL 181 listed ducts with approved closure systems including collars, connections and splices,
- All pressure-sensitive and heat-activated tapes used in the manufacture of rigid fiberglass ducts shall be UL 181A listed,
- All pressure-sensitive tapes and mastics used in the manufacture of flexible ducts shall be UL 181B (tape) or UL 181BM (mastic) listed.

Field-Fabricated Duct Systems

- Ducts:
 - Factory-made ducts for field-fabricated duct systems shall be UL 181 listed.
- Mastic sealants and mesh:
 - Sealants shall be UL 181BM listed, non-toxic, and water resistant,
 - Sealants for interior applications shall pass ASTM tests C 731 (extrudability after aging) and D 2202 (slump test on vertical surfaces),
 - Sealants and meshes shall be rated for exterior use,
 - Sealants for exterior applications shall pass ASTM tests C 731, C 732 (artificial weathering test), and D 2202.
- Pressure-sensitive tapes:
 - Cloth-backed, rubber-adhesive tapes (typical duct tape) shall not be used even if UL 181B rated,
 - Tape used for flexduct shall be UL 181B listed or be aluminum-backed butyl adhesive tape (15 mil. minimum),
 - Tape used for duct board shall be UL 181A listed and so indicated with a UL 181A mark or aluminum-backed butyl adhesive tape (15 mil. minimum).
- Drawbands:
 - Shall be either stainless-steel worm-drive hose clamps or UV-resistant nylon duct ties,
 - Shall have a minimum performance temperature rating of 165 degrees Fahrenheit (continuous, per UL 181A-type test) and a minimum tensile strength rating of 50 pounds,
 - Shall be tightened as recommended by the manufacturer with an adjustable tensioning tool.

FABRICATION AND INSTALLATION

The following are fabrication and installation guidelines that, if carefully followed, will provide a duct installation that is substantially airtight and that will provide proper airflow to each room of the house:

General Issues

- Ducts, plenums, and fittings should be constructed of galvanized metal, duct board, or flexible duct. Building cavities may not be used as a duct or plenum without a sealed duct board or metal liner.
- The air handler box should be airtight,
- Air filters should be easily accessible for replacement, and evaporator coils should be easily accessible for cleaning,
- Ducts should be configured and supported so as to prevent use of excess material, prevent dislocation or damage, and prevent constriction of ducts below their rated diameter;
- Flexible duct bends should not be made across sharp corners or have incidental contact with metal fixtures, pipes, or conduits that can compress or damage the ductwork;
- Flexible ducts should not have bends that exceed 90° unless specified in the design,
- Sheet metal collars and sleeves should be beaded to hold drawbands.

FABRICATE AND INSTALL AN AIRTIGHT DUCT SYSTEM

All Duct Types

- All joints and seams of duct systems and their components should be sealed with mastic, mastic and embedded mesh, aluminum-backed butyl adhesive tape (15 mil. minimum), or pressure-sensitive tape approved for use by the duct manufacturer and meeting UL181 specifications, excluding cloth-backed rubber-adhesive tapes ("approved tape"); cloth-backed rubber-adhesive tapes shall not be used to attach or seal ducts.
- Junctions of collars to distribution boxes and plenums should be sealed with mastic,
- All sealants should be used in strict accordance with manufacturer's installation instructions and within sealants moisture and temperature limitations,
- All tapes used as part of duct system installation should be applied to clean, dry surfaces and sealed with manufacturer's recommended amount of pressure or heat. If oil is present, taped surfaces should be prepared with a cleaner / degreaser prior to application;
- It is recommended that all register boxes should be sealed to the drywall or floor with caulking or mastic.

Flexible Ducts

- Flexible ducts should be joined by a metal sleeve, collar, coupling, or coupling system. At least 2 inches of the beaded sleeve, collar, or coupling must extend into the inner core while allowing a 1-inch attachment area on the sleeve, collar, or coupling for the application of tape,
- The inner core should be mechanically fastened to all fittings, preferably using drawbands installed directly over the inner core and beaded fitting. If beaded sleeves and collars are not used, then the inner core should be fastened to the fitting using #8 screws equally spaced around the diameter of the duct, and installed to capture the wire coil of the inner liner (3 screws for ducts up to 12" diameter, and 5 screws for ducts over 12" diameter);
- The inner core should be sealed to the fitting with mastic or approved tape,
- Tape used for sealing the inner core should be applied with at least 1 inch of tape on the duct lining, 1 inch of tape on the fitting of flange, and wrapped at least three times,
- The outer sleeve (vapor barrier) should be sealed at connections with a drawband and/or three wraps of approved tape,
- The vapor barrier should be complete. All holes, rips, and seams must be sealed with mastic or approved tape.

Metal Ducts and Plenums

- Metal-to-metal connections should be cleaned and sealed in accordance with manufacturer's specifications,
- Openings greater than 1/16 inch should be sealed with mastic and mesh, or butyl adhesive tape,
- Openings less than 1/16 inch should be sealed with mastic or UL-181A listed tape,
- Special attention should be paid to collar connections to duct-board and/or sheet metal; seal around the connection with mastic;
- Connections between collars and distribution boxes should be sealed with mastic,
- At least three equally spaced #8 screws should be used to mechanically fasten round ducts (3 screws for ducts up to 12" diameter, and 5 screws for ducts over 12" diameter),
- Crimp joints should have a contact lap of at least 1½ inches,
- Square or rectangular ducts should be mechanically fastened with at least one screw per side.

Duct Board

- Duct board connections should be sealed with adhesive, mastic, or UL 181A listed pressure-sensitive or heat-activated tape in accordance with manufacturer's specifications.

Duct Support

- Supports should be installed per manufacturer's specifications or per UMC requirements,
- Supports for flexible ducts should be spaced at no more than 4-foot intervals,
- Flexible ducts should be supported by strapping having a minimum width of 1½ inches at all contact points with the duct,
- Supports should not constrict the inner liner of the duct,
- Flexible ducts should have maximum of ½ inch sag per foot between supports,
- Flexible ducts may rest on ceiling joists or truss supports as long as they lie flat and are supported at no more than 4-foot intervals.

Boots

- After mechanically attaching the register boot to floor, wall, or ceiling, all openings between the boot and floor, wall, or ceiling should be sealed with caulk, mastic, or butyl-adhesive tape.

Seal Air Handler

- Openings greater than 1/16 inch should be sealed with mastic and mesh, or butyl adhesive tape,
- Openings less than 1/16 inch should be sealed with mastic or UL 181A listed tape,
- Unsealed access doors should be sealed with UL 181A listed tape.

CHECK REFRIGERANT CHARGE

- For systems with fixed metering devices use evaporator superheat method:
 - Indoor coil airflow must be greater than 350 cfm/ton,
 - Refrigerant system evacuation must be complete (all non-condensables must be removed from the system;
 - In hot, dry climates be cautious to be within range of superheat charging chart or use an approved method.
- For systems with thermostatic expansion valves use the subcooling method.

CHECK COMBUSTION PERFORMANCE

- Check each chamber for correct flame,
- Check for proper drafting.

TEST SYSTEM PERFORMANCE

The following are testing requirements and procedures that must be followed to ensure that the HVAC system has been properly installed. The tests are designed to determine whether:

1. Room-by-room airflows are correct,
 2. Total supply is as designed;
 3. Total return = total supply;
 4. Ducts, plenum, and air handler are tight,
 5. Static pressure is correct.
- Test the system to ensure that it performs properly, by (1) verifying HVAC equipment sizes installed are those specified, (2) measuring duct leakage, and measuring either (3a) fan flow or (3b) supply and return flows and plenum static pressures:
 1. Air conditioner sensible capacity must be no more than 15% greater than the calculated sensible load; fan flow must be greater than 350 cfm/ton; check that the correct size air handler is installed.
 2. Ensure that the duct system does not leak substantially:
 - a. A rough system, including both supply and return but without the air handler, should not leak more than 3% of specified fan flow (cfm leakage measured with HVAC system pressurized to 25 Pa);
 - b. For finished installation, including supply, return, the air handler and finished registers, measured leakage must be less than 6% of nominal fan flow, or measured fan flow or of measured return flow (cfm leakage measured with HVAC system pressurized to 25 Pa);
 - 3a. Measure air handler air flow and static pressure across fan; ensure that total air handler output is within 5% of design and manufacturer specifications at a static pressure within 0.1 in wg of design.
 - 3b. Supply and return air flow, and static pressure requirements: Ensure that supply and return flows are correct, and that the static pressure across the fan is correct:
 - a. Measure room-by-room airflows to ensure that each register is within 15% of Manual D design airflow, and that the entire supply is within 5% of design,
 - b. Measure return airflow to ensure that it is within 5% of the total supply airflow,
 - c. Test static pressure drop across the blower to ensure that it is within 0.1 in wg of design and manufacturer specifications.
 - Duct leakage can be determined using a pressurization or depressurization technique; for details, see ASHRAE Standard 152P, California Energy Commission ACM Manual Appendix F, Minneapolis Duct Blaster™ manual, or other commercially available duct pressurization or depressurization devices;
 - Duct leakage to unconditioned space can be determined with the house pressurization or LBL simplified technique; for details see CEC report P400-91-031CN, Section Six;
 - Fan flow, supply flow and return flow measurements, see Minneapolis Duct Blaster™ manual (or equivalent); alternatively for supply and return flows, use a calibrated flow hood. Do not use a pitot tube, or any type of anemometer to determine these air flows,
 - Static pressure drop across the fan is measured using static pressure probes in the return plenum and in the supply plenum.

REFERENCES

- 1991 Uniform Mechanical Code (UMC) Sections 1002 - 1005 and Appendix A, Standard No. 10-5.
Air Diffusion Council, Flexible Duct Performance & Installation Standards.
ACCA Manual J, Seventh Edition, 1986
ACCA Manual D, New Edition, 1995
ACCA 1515 16th St., NW, Washington, DC 20036, (202) 483-9370
ASHRAE 1791 Tullie Circle, N.E., Atlanta, GA 30329, (404) 636-8400
ASTM E 84 Test for Surface Burning Characteristics of Building Materials
ASTM C 731 Extrudability After Aging
ASTM C 732 Artificial Weathering Test
ASTM D 2202 Slump Test on Vertical Surfaces
California Energy Commission, 1516 9th Street, Sacramento, CA 95814-5512, (800) 772-3300
SMACNA Manual Installation Standards for Residential Heating and Air Conditioning Systems
UL Standard 181 Standard for Factory-Made Air Ducts and Air Connectors
UL Standard 181A Standard for Closure Systems for Use with Rigid Air Ducts and Air Connectors
UL Standard 181B Standard for Closure Systems for Use with Flexible Air Ducts
UL Standard 181BM Standard for Mastic Materials