

Duct Leakage, Sealing & Testing

Massachusetts Energy Code Technical Support Program

Who Is Mass Save®?

- Mass Save® is an initiative sponsored by Massachusetts' gas and electric utilities and energy efficiency service providers, including
 - The Berkshire Gas Company
 - Cape Light Compact
 - Columbia Gas of Massachusetts
 - Eversource Energy
 - Liberty Utilities
 - National Grid
 - Unitil
- The Sponsors of Mass Save work closely with the Massachusetts Department of Energy Resources to provide a wide range of services, incentives, trainings, and information promoting energy efficiency that help residents and businesses manage energy use and related costs.



Presented by:
Performance Systems Development

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Duct Leakage, Sealing & Testing

Massachusetts Energy Code Technical
Support Program



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Agenda



- Consequences of duct leakage
- Duct sealing
- Duct testing
 - How are ducts tested?
 - Duct leakage rates
 - Duct testing verification form
- Summary & Questions

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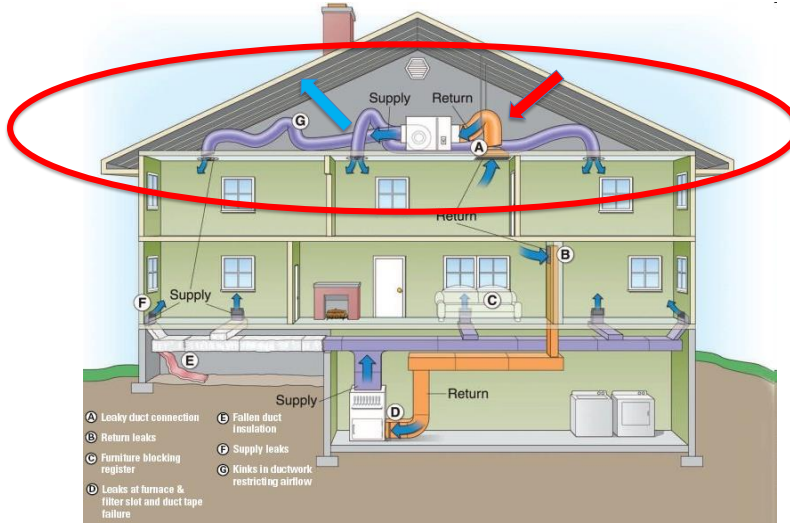


DUCT LEAKAGE

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Duct Leakage

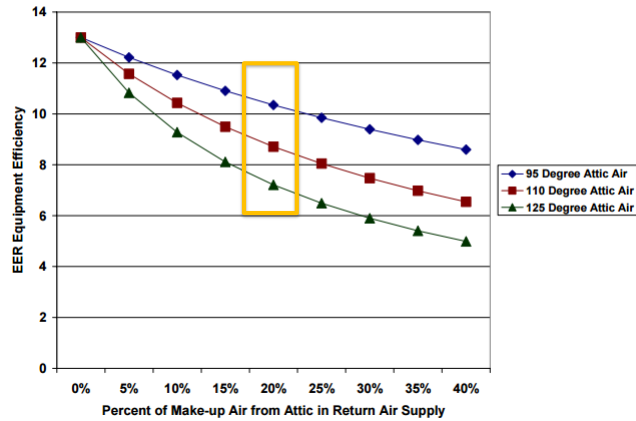
Consequences of duct leakage



Duct Leakage

Consequences of duct leakage

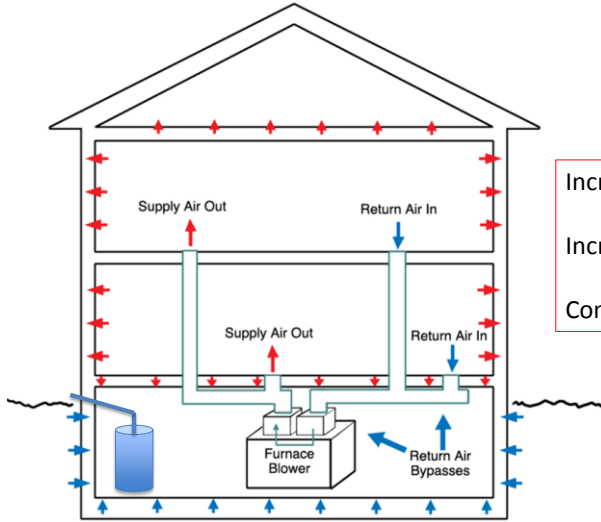
Figure 8-2
 Efficiency Losses Due to Attic Return Leaks



Source: http://dnr.louisiana.gov/assets/TAD/builders_guide/Chapter_08.pdf

Duct Leakage

Consequences of duct leakage

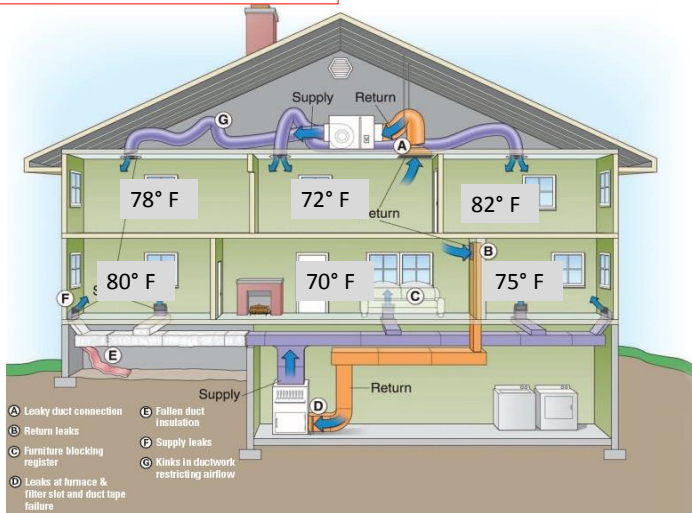


- Increased *envelope* leakage
- Increased moisture risk
- Combustion safety risk

Duct Leakage

Consequences of duct leakage

Discomfort and callbacks

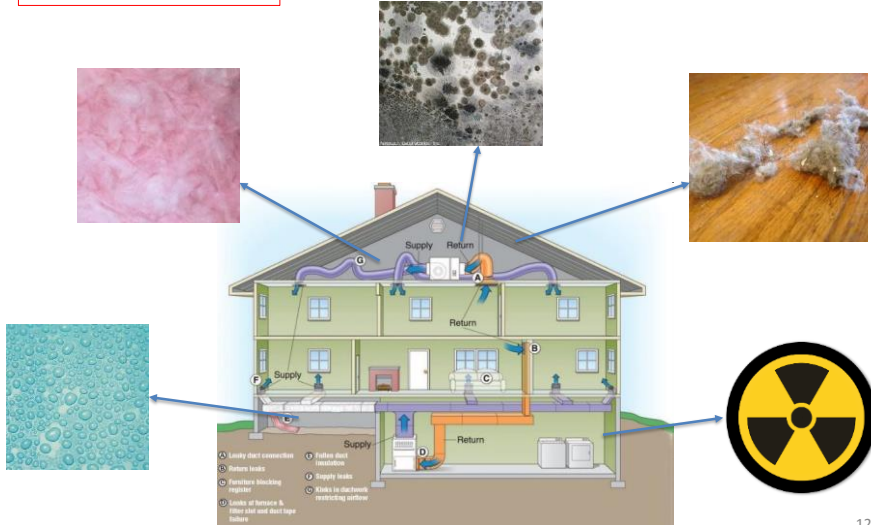


- A Leaky duct connection
- B Return leaks
- C Furniture blocking register
- D Leaks at furnace & filter slot and duct tape failures
- E Fallen duct insulation
- F Supply leaks
- G Kinks in ductwork restricting airflow

Duct Leakage

Consequences of duct leakage

Indoor air quality



Duct Sealing and the Code

Duct Sealing and the IRC



IRC M1601: Joints, longitudinal and transverse seams, and connections in ductwork **shall be securely fastened and sealed** with:

- Welds
- Gaskets
- Mastics
- Mastic-plus-embedded-fabric systems
- Liquid sealants
- Tapes

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Duct Sealing and the IRC



Rigid fibrous glass ducts

- Pressure sensitive tape UL 181A “181 A-P”
- Heat sensitive tape UL 181 A “181 A-H”
- Mastic UL 181 A “181 A-M”



Metallic & flexible air duct

- Pressure sensitive tape UL 181B “181B-FX”
- Mastic UL 181B “181B-M”



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Duct Sealing and the IECC



R403.3.2 (Mandatory): Ducts, air handlers and filter boxes shall be sealed.

- Joints and seams shall comply with either the *International Mechanical Code* or *International Residential Code*

R403.3.2.1 Sealed air handler. Air handlers shall have a manufacturer’s designation for:

- An air leakage of no more than 2 percent of the design air flow rate when tested in accordance with **ASHRAE 193**.

R403.3.2 Duct Sealing (Mandatory)



DAIKIN DP14CH
PACKAGED AIR CONDITIONER
UP TO 14 SEER
2 TO 5 TONS

COOLING CAPACITY:
24,600 - 57,500 BTU/H

Standard Features

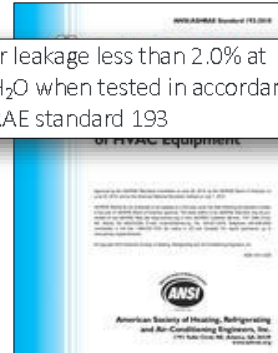
- Energy efficient compressor with internal relief valve
- Multi-Speed ECM blower motor
- Quiet horizontal discharge
- All-aluminum evaporator coil
- Copper tube / aluminum fin condenser coil
- Totally enclosed, permanently lubricated condenser fan motor
- Fully charged system
- 5 KW to 20 KW electric heat kit available as a field-installed option
- AHRF Certified, ETL listed

Cabinet Features

- Heavy gauge galvanized steel cabinet with attractive Nickel Gray powder-paint finish
- Compressor sound blanket
- Cabinet air leakage less than 2.0% at 1.0 inch H₂O when tested in accordance with ASHRAE standard 193
- Cabinet air leakage less than 1.4% at 0.5 inch H₂O when tested in accordance with ASHRAE standard 193
- Fully insulated blower compartment
- Heat compartment access panels
- Louvered condenser coil protection

www.daikincomfort.com

• Cabinet air leakage less than 2.0% at 1.0 inch H₂O when tested in accordance with ASHRAE standard 193



Duct Sealing and the IECC



R403.3.3. Duct testing (Mandatory)*

Ducts shall be pressure tested to determine air leakage

R403.3.4. Duct leakage (Prescriptive)

2015 IECC Duct Leakage Requirement	
Type of Test	Maximum Leakage Rate
Rough-in test with air-handler	4 CFM/ 100 sq.ft.
Rough-in test without air handler	3 CFM/ 100 sq.ft.
Post-construction total leakage to outside	4 CFM/ 100 sq.ft.

***Exception:** A duct air leakage test shall not be required where the ducts and air handlers are located entirely within the building thermal envelope.

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Duct Sealing

MA Code Compliance Residential Baseline Study



- Only 9% of homes had all ducts in conditioned space.
 - This means, over 90% of homes require duct sealing & testing.
- 48% of all homes did not meet the prescriptive path requirement of ≤ 4 cfm/100 sq.ft. duct leakage

Source: 2015-16 Massachusetts Single-Family Code Compliance Baseline Study: Volume 2 – Final Report, NMR Group, Inc & Dorothy Conant, October 21, 2016

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Duct Sealing and the IECC

R403.3.5 Building Cavities (Mandatory).

Building framing cavities **shall not** be used as ducts or plenums



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Duct Sealing and the IECC

Energy Rating Index (ERI) Path Requirement

- For ERI paths (and Stretch Code), a “duct leakage to outdoors” test is required.
- Why?
 - The only Energy Rating Index is the HERS Index
 - RESNET maintains the National Home Energy Rating Standards (HERS)
 - RESNET standards require a leakage to outdoors test on all homes (with very limited exceptions)

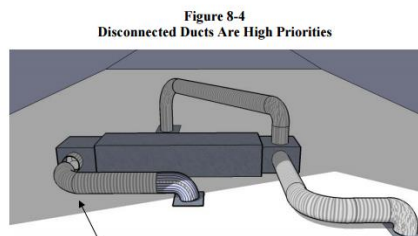
HERS Raters should **NOT** choose the code duct testing exception in Ratings software

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Duct Sealing

Duct Sealing

- Disconnected ducts, fittings not fully inserted, tears or holes in ducts



Disconnected duct. Also, regardless of the type of duct material, in order to maintain designed air flows to each register no bends greater than 45 degrees should ever be made in the duct run.

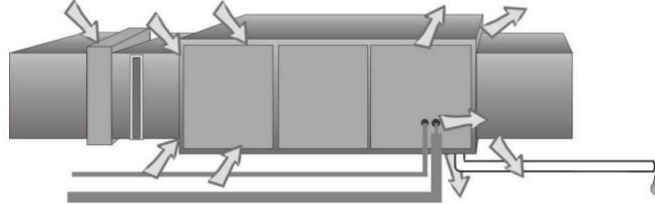
Ducts can become disconnected during initial installation, maintenance, or even normal operation. They should be checked periodically for problems.

Source: http://dnr.louisiana.gov/assets/TAD/builders_guide/Chapter_08.pdf

Duct Sealing

Air handlers & filter boxes

Figure 8-7
Seal All Leaks in Air Handling Unit



Virtually all air handling cabinets come from the factory with leaks, which should be sealed with duct-sealing mastic. Removable panels should be sealed with tape.

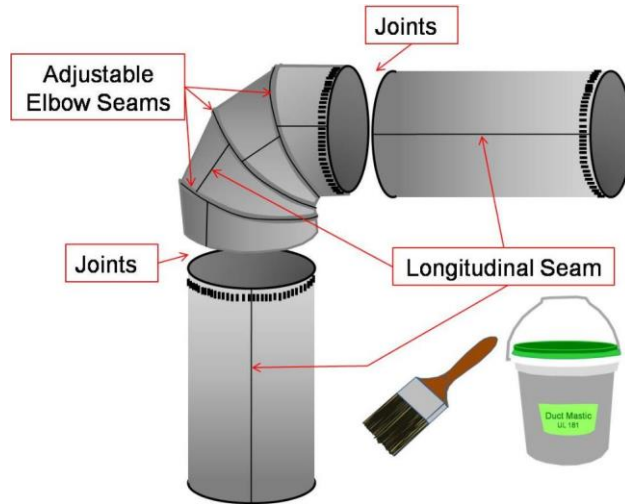
Source: http://dnr.louisiana.gov/assets/TAD/builders_guide/Chapter_08.pdf

Duct Sealing

Air handlers & filter boxes

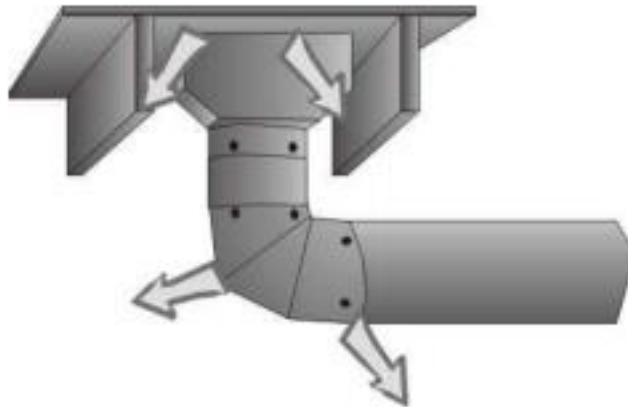


Duct Sealing Elbows and Joints



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Duct Sealing Register boots



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Duct Sealing

Register boots



Courtesy of the Department of Energy's Building America Solution Center (<http://bas.energy.gov>)

Duct Sealing

Metallic Duct



© Performance Systems Development

Duct Sealing

Metallic Duct

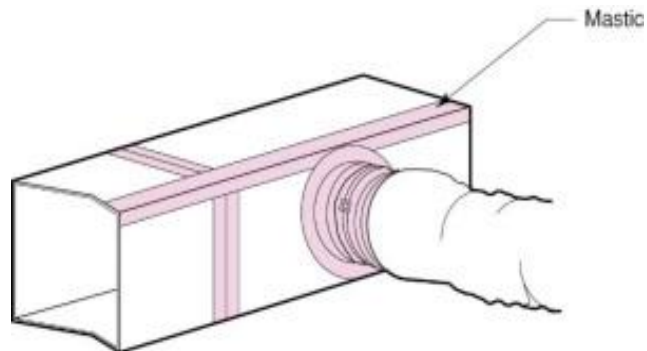


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Duct Sealing

Take-off connections

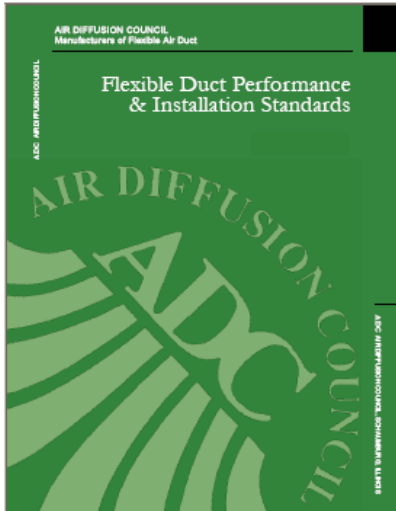
Flex Take-Off from Rigid



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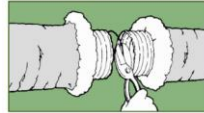
Duct installation

Air Diffusion Council Flex Duct Standard

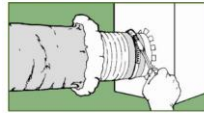


Connections - Using Tape and Fasteners

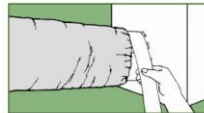
1. After desired length is determined, cut completely around and through duct with knife or scissors. Cut wire with wire cutters. Fold back jacket and insulation.



2. Slide at least 1" [25 mm] of core over fitting and past the bead. Seal core to collar with at least 2 wraps of duct tape. Secure connection with clamp placed over the core and tape and past the bead.



3. Pull jacket and insulation back over core. Tape jacket with at least 2 wraps of duct tape. A clamp may be used in place of or in combination with the duct tape.



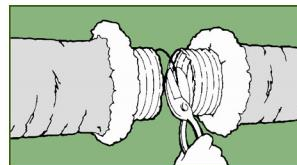
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Duct Installation

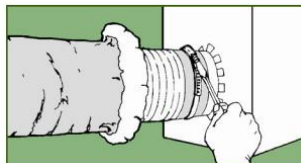
Connections with tape and fastener

1. Cut to length
2. Slide core 2" past bead, seal with 2 wraps of tape
3. Secure with clamp
4. Pull insulation over core and secure with 2 wraps of tape

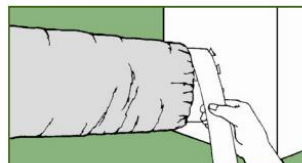
1. After desired length is determined, cut completely around and through duct with knife or scissors. Cut wire with wire cutters. Fold back jacket and insulation.



2. Slide at least 1" [25 mm] of core over fitting and past the bead. Seal core to collar with at least 2 wraps of duct tape. Secure connection with clamp placed over the core and tape and past the bead.



3. Pull jacket and insulation back over core. Tape jacket with at least 2 wraps of duct tape. A clamp may be used in place of or in combination with the duct tape.

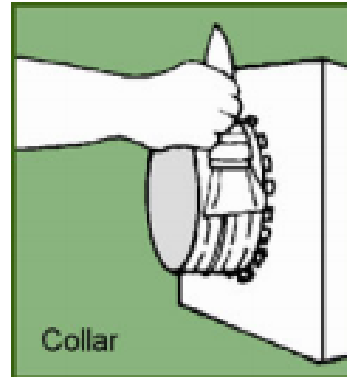


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Duct Installation

Connections with mastic and fastener

- Same steps as tape except apply **mastic** 2" wide past the bead before connecting core



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Duct Sealing

Take-off connections



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Duct Sealing



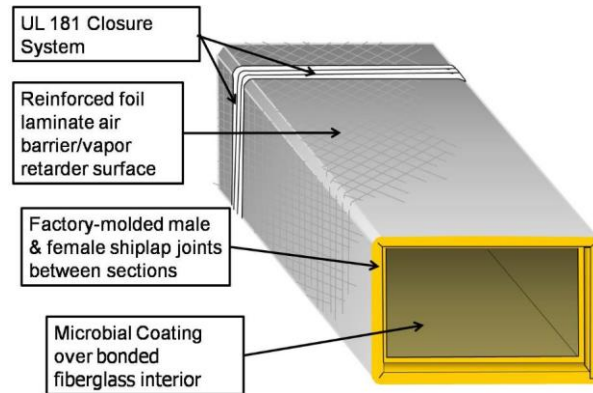
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Fibrous Glass Duct Construction Standards



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Fibrous glass Duct Components



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Fiberglass Duct Closure

Tape width

- 3 inches for R-6 duct (recommended)
- 3 inches for R-8 duct (required)

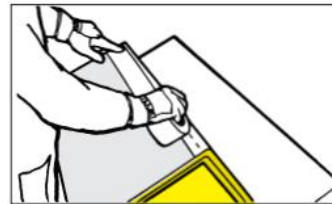


Fig. 4-3A. Applying pressure sensitive aluminum foil tape to longitudinal seam. Hold one end in place firmly and press tape in place, taking care to avoid wrinkles and folds.

Tape application

- Rub tape until facing reinforcement shows clearly through tape
- Take care not to tear at staples



Fig. 4-3B. Rub tape firmly with plastic sealing tool until the facing reinforcement shows clearly through the tape. Avoid tearing or puncturing tape at staples.

Fiberglass Duct Closure

Mastic and glass fabric tape

- Apply mastic over duct seam
- Apply second coat over tape



Fig. 4-5A. Apply a thin coat of mastic over the center of the joint seam. Embed glass fabric in mastic.

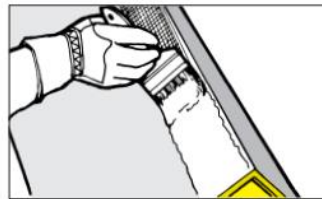


Fig. 4-5B. Apply a second coat of mastic over the glass fabric, filling the scrim pattern.

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Fiberglass Duct Closure

Connections to sheet metal, as in flanges of equipment

- Sheet metal screws and washers to support mechanical load
- Apply mastic and mesh tape
- Two tape widths usually required

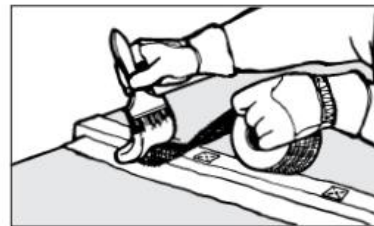


Fig. 4-5C. Glass fabric and mastic are used to seal equipment connections over mechanical fasteners applied to carry the mechanical load.

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Flex Duct Connections to Duct Board

1. Cut hole to fit
2. Coat the collar flange with **mastic** to seal collar to duct board
3. Screw in collar or insert and bend tabs

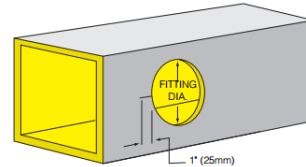


Fig. 4-6A. Cutting hole in duct board for flexible duct connection.

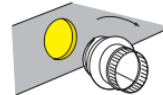
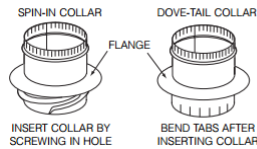


Fig. 4-6B. Installing spin-in collar.

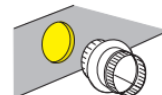


Fig. 4-6C. Installing dove-tail collar.

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Flex Duct Connections to Duct Board

- Seal flex duct core to collar
- Pull insulation snug to duct board
- Install flex duct per manufacturer's instructions

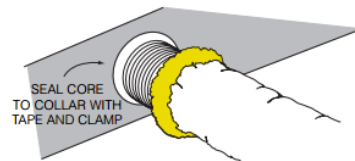


Fig. 4-6D. Installing flexible duct over collar.

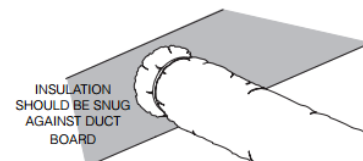


Fig. 4-6E. Install flexible duct to collar according to manufacturer's instructions.

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Duct Mechanically Fastened AND Sealed



A



Connection in place but not sealed.

Mechanically fastened and sealed.

IRC 1601.4.1 Duct connections shall be sealed and mechanically fastened

HVAC System Quality Installation Rater Checklist

DUCT TESTING



Duct testing basics

Duct Leakage Testing Equipment



Connection to return
or air handler



Fan and Connector



Digital Gauge

Duct testing basics



1. Seal supplies and returns
2. Attach fan to return register or air handler cabinet
3. Depressurize ducts to negative 25 pascals
4. Measure the airflow at 25 pascals

High airflow (CFM25) = High leakage

Low airflow (CFM25) = Low leakage



Duct Tightness Verification



MA N1103.3.3: Testing and verification of ducts to be done by:

- Certified HERS Rater, or
- Certified HERS Field Inspector, or
- BPI Certified Professional



Under discussion for adoption:
Adding sheet metal contractors to the list

Duct Tightness Verification



© The Energy Conservatory

Prescriptive path only

2015 IECC Duct Leakage Requirement	
Type of Test	Maximum Leakage Rate
Rough-in test with air-handler	4 CFM/ 100 sq.ft.
Rough-in test without air handler	3 CFM/ 100 sq.ft.
Post-construction total leakage to outside	4 CFM/ 100 sq.ft.

Exception: Duct tightness test is not required if the air handler and all ducts are located within conditioned space.
Note: Total leakage to the outside test required when using ERI path

DOCUMENTATION

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Duct Leakage Verification

1. Plan review:

Identify duct location

2. Notify the applicant:

Issue duct sealing verification form with approved plans


3. Final inspection checklist:

Add check box, "Duct Sealing Verification Form received"

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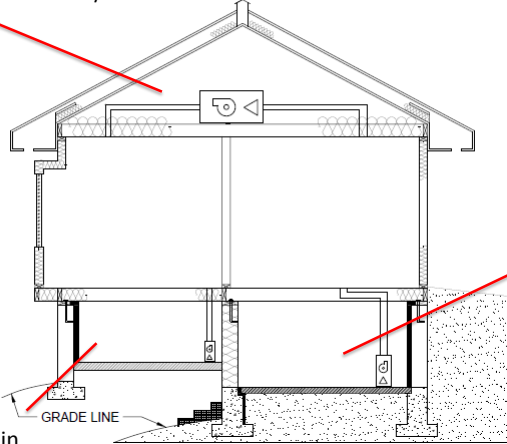
Duct Leakage Verification

1) Identify Duct Location



Energy Code
Technical Support
Program

Air handler or ducts in attic? Y/N



Air handler or ducts in basement? Y/N


GRADE LINE

Air handler or ducts in crawlspace? Y/N

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Duct Leakage Verification

2) Issue duct verification Form



Energy Code
Technical Support
Program

DUCT TIGHTNESS TEST REQUIRED
(UNLESS AIR HANDLER AND ALL DUCTS
ARE WITHIN CONDITIONED SPACE)

II. Heating and Cooling System Duct Leakage

All portions of the ducts are located entirely within the building thermal envelope. Testing is not required.

Duct leakage test

Testing company: _____ Phone: _____

Tester Name (print): _____ Signature: _____ Date: _____

BPI or HERS Rater certification number: BPI no: _____ HERS Rater no: _____

Total duct leakage test (choose 1):

Rough-in w/ air handler (must be ≤ 4.0 CFM/100 ft²) Rough-in w/o air handler (must be ≤ 3.0 CFM/100 ft²)

Post construction (must be ≤ 4.0 CFM/100 ft²)

Test Result:

System 1:

Fan Flow at 25 Pascals (CFM25) _____ CFM Conditioned Floor Area (CFA) served by system = _____ ft²

CFM25 / CFA x 100 = _____ CFM/100 ft²

System 2 (if present):

Fan Flow at 25 Pascals (CFM25) _____ CFM Conditioned Floor Area (CFA) served by system = _____ ft²

CFM25 / CFA x 100 = _____ CFM/100 ft²

*Note: When following the Energy Rating Index (ERI) path, a leakage to outdoors test is required per RESNET standards.

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Duct Leakage Verification

3) Final Inspection Checklist



LOW-RISE RESIDENTIAL NEW CONSTRUCTION
Massachusetts Energy Code 9th Edition
Plan Review Checklist (v 05-02-2018)

Applicant Name: _____ Applicant Phone: _____
Project Address: _____ Date: _____
Reviewed by: _____

Indicate which Compliance Path is being used (R401.2)

Path 1 Path 2 Path 3 (required for Stretch Code)

Path 1. Prescriptive – Sections R401 through R406 include prescriptive energy conservation and specifications where applicable to building.

Window & Door	Skylight	Ceiling	Floor	Floor	Basement wall	Insulation depth	Crawlspace wall
Minimum R-value							

Option A Option B

LOW-RISE RESIDENTIAL NEW CONSTRUCTION
Massachusetts Energy Code 9th Edition
Final Documentation / Inspection Checklist (v 05-02-2018)

Applicant Name: _____ Applicant Phone: _____
Project Address: _____ Date: _____
Reviewed by: _____

1. Insulation, windows, doors, skylights. One of the following alternatives must be checked:

Alternative	Minimum U-value	Minimum R-value	Minimum U-value	Minimum R-value	Minimum U-value	Minimum R-value	Minimum U-value	Minimum R-value
A. Prescription	U-0.30	R-5.00	U-0.30	R-5.00	U-0.30	R-5.00	U-0.30	R-5.00
B. UA Equipment	U-0.30	R-5.00	U-0.30	R-5.00	U-0.30	R-5.00	U-0.30	R-5.00
C. Annual Energy Cost	Insulation values must be based on the approved UA of the equipment. If the UA is not provided, the UA must be based on the UA of the equipment. The UA must be based on the UA of the equipment. The UA must be based on the UA of the equipment.							
D. Energy rating index (ERI) and Approved Alternatives	MANDATORY FOR STRETCH CODE COMPLIANCE							

4. Duct sealing - Mandatory (R403.3.2) – All ducts, air handlers and filter boxes are sealed

5. Duct testing and leakage (R403.3.3 and .4) – Duct leakage test results received. **Exception if all ducts and air handlers are within the building envelope.** Leakage is not over 4 cubic ft. per 100 sq. ft. of conditioned floor area. (3 cubic ft. if test was performed at rough-in and without air handler installed) **NOTE: Leakage may be higher if house complies using performance path (R406)**

6. Duct Insulation (R403.3.1) – Space conditioning ductwork in vented attics must be R-8 (or R-6 if <3" diameter). Space conditioning ductwork in all other areas must be R-6. (R-4.2 if <3" diameter.) **Exception: ducts or portions thereof located completely inside the building thermal envelope.**

Renewable energy source	Minimum SEER value	Minimum SEER value
Heat pump	13	13
Water heater	0.90	0.90
Boiler	0.80	0.80
Space heating	0.80	0.80
Space cooling	13	13
Water heating	0.90	0.90
Boiler	0.80	0.80
Space heating	0.80	0.80
Space cooling	13	13

9. Mechanical ventilation - Mandatory (M404.2) as well as...
 10. Lighting - Mandatory (M404.3) - Minimum 70% of light fixtures in apartment buildings must be high efficiency (e.g. fluorescent or LED)
 11. Energy Star - Mandatory (M404.4) - Energy Star rated appliances must be installed in apartment buildings, except for ranges, cooktops, ovens, and dishwashers (when applicable), if placed in the space where the heating system is located or is being used.

Duct leakage section used during final inspection

Summary



- Seal all joints, seams & connections using proper materials & technique
- All duct testing and verification must be completed by a certified professional
- Duct leakage tests help quantify leakage and will sometimes help diagnose problems
- Tight ducts reduce energy waste and improve comfort, safety and indoor air quality

Questions

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Energy Code Support

Questions about the energy code?

Energy Code Support Hotline:

855-757-9717

Energy Code Support Email:

energycodesma@psdconsulting.com

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Energy Code Field Guides



Field Guides for Code Officials
and Builders/Trades at:

SuccessWithEnergyCode.com

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Residential New Construction

Incentives for energy efficient building and renovating



- **Low-Rise New Construction**

- Performance Path – based upon Electric and Fuel savings, plus a % adder as compared to MA baseline – incentives up to \$10,000

- **High-Rise New Construction and all Master Metered Natural Gas**

- Incentives based upon modeling by Program Manager

Incentives also offered for existing buildings.
Visit www.MassSave.com for the details.

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Residential New Construction – Incentives



Blended Savings Approach (BSA)

Single Family BSA Incentive Calculation	
A	Electric Savings * \$0.35 / kWh
B	Fuel Savings * \$35 / MMBtu
C	Percent Savings * \$3,000
Participant Incentive	A + B + C
Rater Incentive	\$350

Multifamily BSA Incentive Calculation	
A	Electric Savings * \$0.35 / kWh
B	Fuel Savings * \$35 / MMBtu
C	Percent Savings * \$2,000
Participant Incentive	A + B + C
Rater Incentive	\$100

Details at:
www.masssave.com/en/saving/residential-rebates/new-construction

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Thanks!

Massachusetts Energy Code Technical Support Program

