

9th Edition Mechanical and Service Water Heating

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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Agenda



- Related Codes and Code Sections
 - IECC Section R403
- Mandatory & Prescriptive Requirements
- Ducts
 - Duct Insulation
 - Duct Sealing
 - Duct leakage and Testing
- Service Water Heating
 - Circulating Systems
 - Hot water pipe Insulation
- Other Provisions
 - Piping insulation
 - Equipment sizing
 - Pools & Spas
- Summary
- Questions

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Mandatory vs Prescriptive



Prescriptive

- Hot water boiler outdoor temperature setback
- Duct Insulation
- Duct Leakage
- Demand Recirculation systems
- Hot water pipe insulation

Mandatory

- Controls
- Sealing
- Duct testing
- Building Cavities
- Heated Water Circulation and Temperature maintenance systems
- Equipment sizing and efficiency rating
- Pools and permanent spa energy consumption

Mandatory requirements need to be met regardless of the compliance path

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DUCT SYSTEMS

Duct Insulation, Duct Sealing, Duct Testing, Duct leakage

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Baseline Study Results



- Only 9% of homes had all ducts in conditioned space & 49% had no ducts in conditioned space. All these systems require testing
- Average total duct leakage of all the homes was
 - 9 cfm/100 sq.ft. for homes built to 2012 IECC
 - 9.4 cfm/100 sq.ft. for homes built to Stretch Code

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

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ACCA Manuals

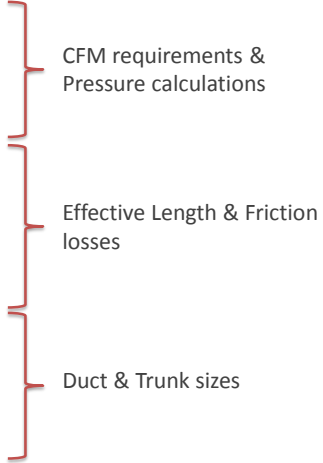


- Manual D – Duct Design
- Manual J – Residential Load Calculations
- Manual S – Equipment sizing

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ACCA Manual D Checklist

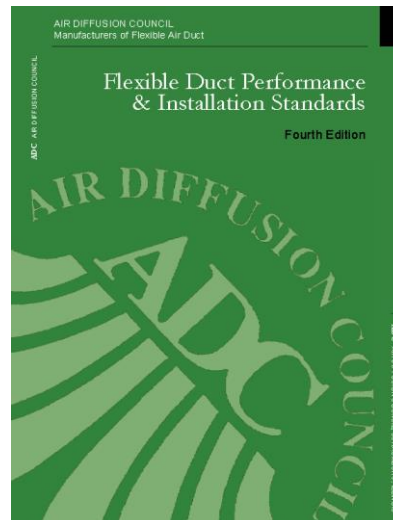
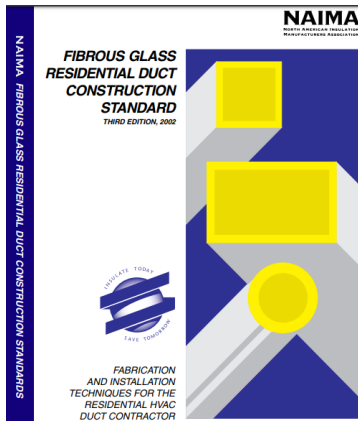
ACCA's Manual D Residential Duct Design Checklist		
Key Item	Check	Questions to Ask
Information from load calculation	CFM for each room	Does each room have a heating and cooling CFM assigned? (Proportioned air supply based on Manual J8 room-by-room load calculations) (C)
Manufacturer's Data	Manufacturer's External Static Pressure (ESP)	According to the manufacturer's data will the fan produce the specified airflow at the specified static pressure? (Manufacturers produce a graph that relates air flow and static pressure) (A) (B)
	Accessory and device pressure losses	Did the contractor submit the manufacturer's data specifying the pressure drop for any item in the air stream like a high efficiency filter or a hot water coil? (C)
Manual D Friction Worksheet	Available Static Pressure (ASP)	Are supply outlets, return grilles, and balancing dampers listed at a standard 0.03? (C)
	Total Effective Length (TEL)	Are the pressure drops listed for other external devices: filters, coils, etc...? (C)
	Friction Rate design value	Did the contractor calculate the TEL by adding the longest Supply Total Effective Length and the longest Return Total Effective Length? (Total Effective Length = the length of the duct from outlet back to unit + the effective length for all fittings, i.e., elbows, reducers, take-offs, etc...) (D)
Air Distribution System Design	Branch Lead Size	Did the contractor use the Friction Rate Chart or calculate Friction Rate [FR = ASP x 100 / TEL] (E)
	Trunk Size	Did the contractor size the ducts based on the design CFM, friction rate, and the duct material used? (C)
	Return Trunk Duct Velocities	Did the contractor select a supply trunk duct large enough to accommodate all the supply branch leads? (D)
	Return air path	Did the contractor select the return trunk duct large enough to meet the lower return air velocity requirements? (D)
Manual T	Register and Grille Face Velocities	Verify each occupied room has an open air path (ACCA recommends a ducted return for each bedroom, den, library, etc...)
		Does the air velocity across the register or grille exceed the Recommended Velocity Chart? (Grille manufacturers list the face velocity for grilles and registers at a given CFM, e.g., 12 x 4 - Model XYZ, 500fpm at 120cfm) (I)



2015 IRC M1601.1 Duct Construction

Duct systems should be installed in accordance with

- ACCA Manual D
- Manufacturer's instructions



Source: 1) <https://insulationinstitute.org/wp-content/uploads/2015/11/AH119.pdf>

2) http://a-actionhomeinspection.com/wp-content/uploads/pdfs/Flex_Ductwork_Installation.pdf

2015 IRC M1601.1 Duct Construction

Manual D – Bad installation



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© Performance Systems Development

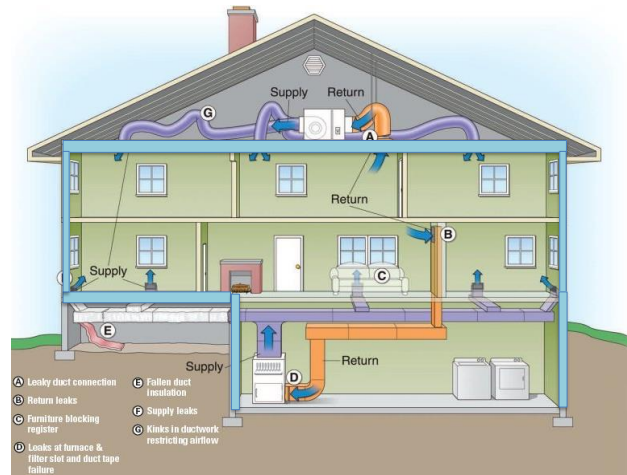
R403.3.1 Duct Insulation



2015 IECC	
Location of ducts	R-value of duct insulation
Supply <u>and Return</u> ducts in attic	R-8 when ≥ 3 inch diameter
	R-6 when ≤ 3 inch diameter
Supply and Return ducts elsewhere	R-6 when ≥ 3 inch diameter
	R-4.2 when ≤ 3 inch diameter

Exception: Ducts located completely inside the building thermal envelope

R403.3.1 Duct Insulation



Which duct require insulation? What is the required R-value?

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R403.3.1 Duct Insulation

High-velocity ducts



Ducts $\leq 3''$ are generally only found in high-velocity systems

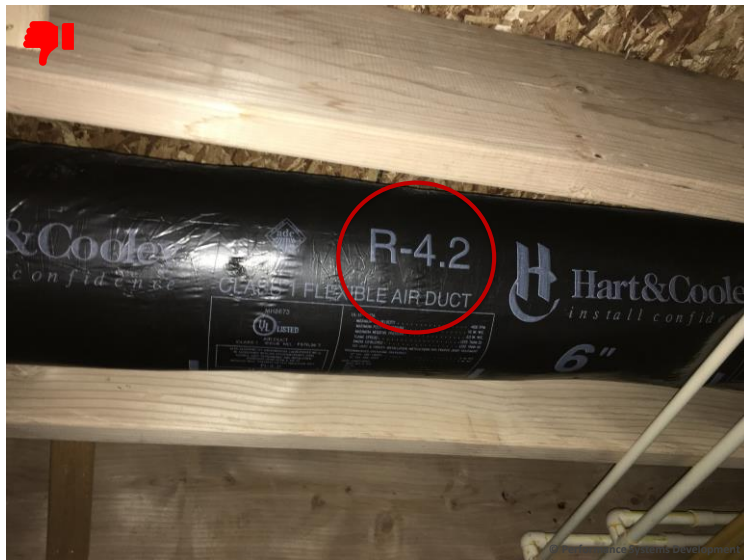
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R403.3.1 Duct Insulation



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R403.3.1 Duct Insulation



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R403.3.1 Duct Insulation



R - 8 insulation

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R403.3.2 Duct Sealing (Mandatory)

- The following duct system components must be sealed:
 - Ducts
 - Air handlers
 - Filter boxes
- Joints and seams shall comply with either the *International Mechanical Code* or *International Residential Code*
- Building cavities are not allowed as supplies or returns

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R403.3.2 Duct Sealing (Mandatory)



DP14CH

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

PACKAGED AIR CONDITIONER
UP TO 14 SEER
2 TO 5 TONS



■ Contents

- Nomenclature.....
- Product Specifications.....
- Expanded Cooling Data.....
- Airflow Data.....
- Heater Kit Specifications.....
- Dimensions.....
- Wiring Diagram.....
- Accessories.....

■ 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-Chrome powder painted 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
- Hail resistant access panels
- Louvered condenser coil protection



52-DP14CH

www.daikincomfort.com

11/05
September 05

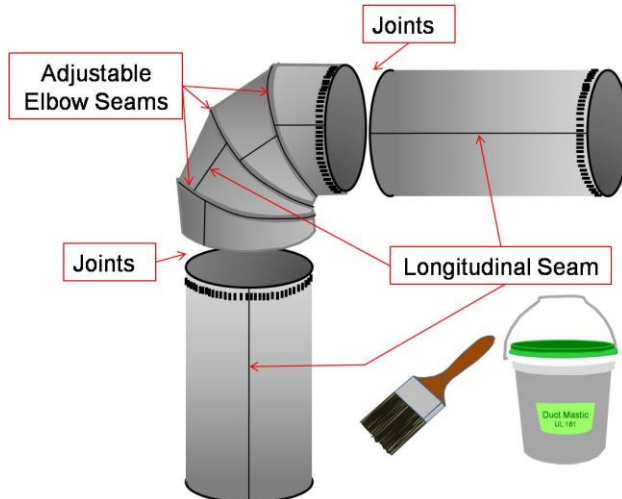
R403.3.2.1 Air handlers shall have an air leakage rate no more than 2% of the design

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



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R403.3.2 Duct Sealing (Mandatory)



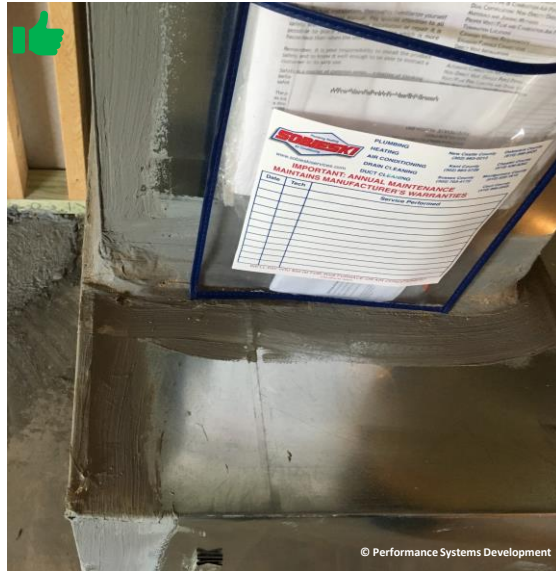
basc.pnnl.gov

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R403.3.2 Duct Sealing (Mandatory)



R403.3.2 Duct Sealing (Mandatory)



R403.3.2 Duct Sealing (Mandatory)



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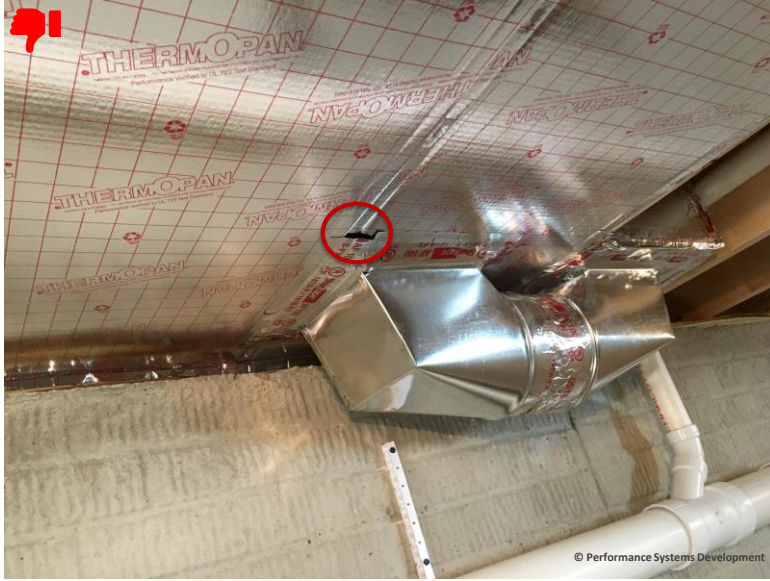
R403.3.2 Duct Sealing (Mandatory)



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R403.3.2 Duct Sealing (Mandatory)



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R403.3.2 Duct Sealing (Mandatory)



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R403.3.2 Duct Sealing (Mandatory)



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R403.3.2 Duct Testing (Mandatory)

- Ducts shall be pressure tested to determine air leakage during rough-in or post construction.
- A written report of the results of the test shall be signed by the party conducting the test and provided to the code official.

MA Amendment: Post-construction or rough-in testing and verification shall be done by

- HERS Rater
- HERS Field Inspector
- BPI Certified Professional



Building
 Performance
 Institute, Inc.

Helping you become healthy, comfortable and efficient at home

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R403.3.2 Duct Leakage (Prescriptive)



2015 IECC Duct Leakage Requirement	
Location of ducts	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.

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R403.3.2 Duct Leakage (Prescriptive)



Duct leakage test result:

Square footage of conditioned floor area served by HVAC system: _____ ft²

Tested leakage rate: _____ cfm₂₅

Formula: (cfm₂₅/ft² of conditioned floor area served) x 100 = Duct Leakage Result

_____ cfm₂₅ / _____ ft² of conditioned floor area x 100 = _____ cfm per 100 ft² @25 Pa

Pass Fail

Testing company name: _____ Test date: _____

A duct leakage test has been performed on the HVAC system for the location above, and the duct system meets the minimum leakage requirements outlined in the 2015 International Energy Conservation Code.

Signature: _____ Date: _____

Find a certified professional:

<http://www.nehers.org/find-hers-rater>

<http://www.bpihomeowner.org/find-a-contractor>

<http://www.bpihomeowner.org/find-a-contractor>

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SERVICE WATER HEATING

Heated water circulation and temperature maintenance systems,
Demand recirculation systems, Hot water pipe insulation

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R403.5.1 Heated Water Circulation and Temperature(Mandatory) Circulation Systems

- Heated water circulation systems shall be provided with a circulation pump.
 - No gravity or thermosyphon systems allowed.
- The system return pipe shall be a **dedicated return pipe or a cold water supply pipe.**

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R403.5.1 Heated Water Circulation and Temperature(Mandatory) Circulation Systems



The following controls are required:

- Controls for the pumps shall start/turn off based on demand for hot water.
- When the desired temperature is reached the controls shall turn off the pump automatically.

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R403.5.2 Demand Recirculation Systems



Required if a recirculation pump pumps water from a heated water supply pipe back to the heated water source through a **cold water supply pipe**. The following controls are required

- Control shall start the pump based on fixture usage or flow of tempered water
- Control shall limit the temperature of water entering the cold water piping to 104°F

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R403.5.3 Hot Water Pipe insulation (Prescriptive)

IECC 2015 Hot Water Pipe Insulation of R-3 required for

- 1) hot water piping $\frac{3}{4}$ inch nominal diameter and larger
- 2) for piping serving more than one dwelling unit
- 3) Piping located outside conditioned space
- 4) Piping from water heater to distribution manifold
- 5) Piping located under a floor slab
- 6) Buried in piping
- 7) Supply and Return piping in recirculation systems other than demand recirculation systems

Piping located outside conditioned space should be insulated even if the nominal diameter is less than $\frac{3}{4}$ in.

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R403.5.3 Hot Water Pipe insulation (Prescriptive)

From heater to manifold



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OTHER PROVISIONS

Mechanical system piping insulation, equipment sizing and efficiency rating, pools and permanent spa energy consumption

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R403.4 Mechanical System Piping Insulation (Mandatory)

Mechanical system piping capable of carrying fluids above 105⁰ F or below 55⁰ F shall be insulated to a minimum of R-3.

- Heat Pumps/Ductless mini split systems
 - Components
- Boilers/Water Heaters for Hydronic Systems

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R403.7 Equipment sizing and efficiency rating (Mandatory)



Heating and Cooling equipment shall be sized in accordance with ACCA Manual S based on building loads calculated in accordance with ACCA Manual J.

R403.7 Equipment sizing and efficiency rating (Mandatory)



energy vanguard Project Summary
Entire House
Energy Vanguard

Job: Sample Report
 Date: 11/15/2012
 By: abel

1924 Clairmont Rd Ste 50, Decatur, GA 30033 Phone: (334) 707-2007 Email: info@energyvanguard.com Web: www.energyvanguard.com

Project Information

For: Sample Report
 Auburn, AL 36830

Notes: ***Typical Reports Include - Summary, Summary by Zone, Analysis, Short Room Form, Components, AED Report, Plan Sketch***

Location Design Information

Weather: Auburn, AL, US **outside 99%/1% temps**

Winter Design Conditions		Summer Design Conditions	
Outside db	22 °F	Outside db	93 °F
Inside db	70 °F	Inside db	75 °F
Design TD	48 °F	Design TD	18 °F
		Daily range	14
		Relative humidity	50 %
		Moisture difference	45 gr/lb

Heating Summary

Structure	58517 Btuh
Ducts	1713 Btuh
Central vent (0 cfm)	0 Btuh
Humidification	0 Btuh
Blow-off	0 Btuh
Equipment load	60230 Btuh
total heating load at peak conditions	60230 Btuh

Sensible Cooling Equipment Load Sizing

Structure	34536 Btuh
Ducts	837 Btuh
Central vent (0 cfm)	0 Btuh
Blower	0 Btuh
Use manufacturer's data	n
Rate/swing multiplier	0.98
Equipment sensible load	34665 Btuh

Infiltration

Method	Simplified Average
Construction quality	0
Fireplaces	0

Latent Cooling Equipment Load Sizing

Structure	4388 Btuh
Ducts	367 Btuh
Central vent	0 Btuh
Equipment latent load	4754 Btuh
total cooling load at peak conditions	4754 Btuh
Equipment total load	39420 Btuh
Req. total capacity at 0.78 SHR	5.7 ton

Infiltration

Method	Heating	Cooling
Area (ft²)	3552	3552
Volumes (ft³)	37,726	37,726
Air changes/hour	0.37	0.19
Equip. AVF (cfm)	233	119

total house size

Area (ft²): 3552
 Volumes (ft³): 37,726
 Air changes/hour: 0.37
 Equip. AVF (cfm): 233

Source: http://live-ec-energyvanguard.pantheonsite.io/sites/default/files/2_ev_hvac_design_sample_manual_j_detailed_reports.pdf

R403.7 Equipment sizing and efficiency rating (Mandatory)



#	KEY ITEM	CHECK	QUESTIONS TO ASK	CIRCLE ANSWER*
1	DESIGN TEMPERATURES	✓ Indoor Design Temperature	Is the indoor design temperature for Heating per Local Code on 70°F (21°C) at 30% RH?	YES NO NA
		✓ Outdoor Design Temperature	Is the indoor design temperature for Cooling per Local Code on 75°F (24°C) at 50% RH? (or 85% for humid climate, 45% for dry climate)?	YES NO NA
2	WINDOWS & GLASS DOORS	✓ U-values and SHGC values	Are the SHGC and U-values reasonable for the window types and frame constructions? (see Table 2 of MJE)	YES NO NA
		✓ Shading Adjustments	Have window shading (curtains, drapes, insect screens, tinting, etc.) adjustments been made?	YES NO NA
		✓ Overhang Adjustments	Have roof overhang adjustments been made?	YES NO NA
		✓ Total Area	Is the total area for the windows & glass doors roughly equal to the area shown on the drawing plans?	YES NO NA
		✓ Exposure Directions	Do the exposure directions [North (N), North-East (NE), etc.] appear correct?	YES NO NA
3	SKYLIGHTS	✓ U-values and SHGC values	Are the SHGC and U-values appropriate for the skylight types and frame constructions? (see Table 2 of MJE)	YES NO NA
		✓ Shading Adjustments	Have adjustments been made for drapes, tinting and reflective coatings?	YES NO NA
		✓ Total Area	Is the total area for the skylight roughly equal to the area shown on the drawing plans?	YES NO NA
4	DOORS WOOD, METAL	✓ None	---	---
		✓ Insulation	Are correct wall insulation R-values taken into account when the wall loads are calculated?	YES NO NA
5	WALLS ABOVE GRADE, BELOW GRADE	✓ Total Area	Is the total area for the walls equal to the area shown on the drawing plans?	YES NO NA
		✓ Insulation	Is correct ceiling insulation R-value taken into account when the ceiling load is calculated?	YES NO NA
6	CEILINGS	✓ Radiant Barrier	If applicable, does the load calculation take credit for a radiant barrier?	YES NO NA
		✓ Roof color and material	Is correct roof color and material taken into account when the ceiling load is calculated?	YES NO NA
		✓ Total Area	Is the total area for the ceilings equal to the area shown on the drawing plans?	YES NO NA
7	FLOORS	✓ Insulation	Is the floor insulation and type of construction representative of what is built/planned?	YES NO NA
8	INFILTRATION	✓ Envelope Tightness	Is the listed envelope tightness (tight, semi-tight, average, semi-loose, loose) appropriate?	YES NO NA
		✓ Above grade volume	Is the total above grade volume equal to what is shown on the drawing plans?	YES NO NA
9	INTERNAL GAINS	✓ Appliances	Are the appliance gains 1200 Btu/h, 2400 Btu/h or a value recommended by MJE?	YES NO NA
		✓ Occupants	Is Maximum Number of Occupants = Number of Bedrooms + 1? - Is Btu/h (sensible) = 250 x Number of Occupants? - Is Btu/h (latent) = 200 x Number of Occupants?	YES NO NA
		✓ Duct Location	If located in an unconditioned space, are the ducts insulated (appropriate R-value)?	YES NO NA
10	DUCTS	✓ Duct Tightness	Is the duct tightness category "average" or higher (i.e. normally sealed, extremely sealed)?	YES NO NA
		✓ Insulation Fans	Are intermittent bathrooms and kitchen fans excluded from the infiltration calculations?	YES NO NA
11	VENTILATION	✓ Continuous Exhaust Fans	Are dedicated exhaust fans (continuous) included in the calculations?	YES NO NA
		✓ Heat Recovery Equipment	Are the heat recovery equipment and/or a ventilating dehumidifier included in the calculations (if applicable)?	YES NO NA

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R403.7 Equipment sizing and efficiency rating (Mandatory)



Equipment Selection Checklist		Equipment Selection using an Example Checklist																										
#	K																											
1	Des	Is the total heating capacity of the selected equipment $\leq 140\%$ of the designed total heating load? (If not reduce equipment size) E																										
2	OE Per Dat	Is the total cooling capacity of the selected equipment $\leq 115\%$ of the designed total cooling load? (If not reduce equipment size) F																										
3	Epi Per	Does the "Sensible" and/or "Latent" capacities of the selected equipment meet the load's requirements? G																										
		If a heat pump in a very cold climate (heating is primary concern) does the total cooling capacity of the selected equipment exceed 125% of the designed total cooling load?																										
4	Auxiliary Heat	Does the electric auxiliary heat provide the necessary BTU's to make up difference in capacity from the heat pump's balance point to the design load conditions? H	<table border="1"> <tr> <td>Sensible Heat Ratio versus Temperature Design Value</td> <td>85% \approx 19° Design Temp</td> <td>Heat Pump Balance Point and Total Heat Load</td> <td>30,281 Btu/h</td> <td>20,000 Btu/h design condition. More capacity is required. (All Conditions do not have a balance point)</td> </tr> <tr> <td>SHR</td> <td>Recommended Value, Design</td> <td>Sensible Heat Gain Design Temp + 1.1</td> <td></td> <td></td> </tr> <tr> <td>Below 0.80</td> <td>21°F</td> <td></td> <td></td> <td></td> </tr> <tr> <td>0.80 - 0.85</td> <td>19°F</td> <td>Auxiliary Heat (KW)</td> <td>10 KW</td> <td>In this example the auxiliary heat is electric. The formula for electric heat is KW = Btu/h ÷ 3,413</td> </tr> <tr> <td>Above 0.85</td> <td>17°F</td> <td>Gas, Oil</td> <td></td> <td></td> </tr> </table>	Sensible Heat Ratio versus Temperature Design Value	85% \approx 19° Design Temp	Heat Pump Balance Point and Total Heat Load	30,281 Btu/h	20,000 Btu/h design condition. More capacity is required. (All Conditions do not have a balance point)	SHR	Recommended Value, Design	Sensible Heat Gain Design Temp + 1.1			Below 0.80	21°F				0.80 - 0.85	19°F	Auxiliary Heat (KW)	10 KW	In this example the auxiliary heat is electric. The formula for electric heat is KW = Btu/h ÷ 3,413	Above 0.85	17°F	Gas, Oil		
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Above 0.85	17°F	Gas, Oil																										

R403.10 Pools and Permanent Spa Energy Consumption (Mandatory)



- R403.10.2– Electric power to heaters shall be controlled by a readily accessible on-off switch that is an integral part of the heater mounted on the exterior of the heater, or external to and within 3 feet of the heater.
- Time switches that can automatically turn on and turn off heaters and pumps according to a preset schedule

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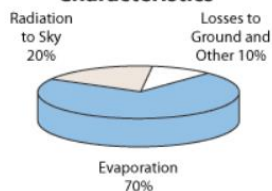
R403.10 Pools and Permanent Spa Energy Consumption (Mandatory)



Pool Covers

Outdoor heated pools should be covered by vapor retardant pool covers.

Outdoor Pool Energy Loss Characteristics



Source: <https://www.michigan.gov/>



Source: basc.pnnl.gov

Exception: If more than 70% of the energy for heating is from site-recovered energy (E.g. heat pump) or from a solar energy source

Summary

- Supply and return ducts in attics with nominal diameter greater than 3 in require R-8 insulation; elsewhere R-6 is required
- Sealing duct systems is mandatory.
- Duct insulation and duct leakage are prescriptive requirements; Duct sealing and duct testing are mandatory
- Gravity or thermosyphon circulation systems for hot water are not allowed
- Any hot water pipe greater than $\frac{3}{4}$ in DN should be insulated with R-3; any hot water pipe outside conditioned space should also be insulated
- System sizing per ACCA Manual S is mandatory
- Outdoor heated pools should have vapor retardant pool covers

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Reference Material

- NAIMA Fibrous Glass Residential Duct and Construction Standards : <https://insulationinstitute.org/wp-content/uploads/2015/11/AH119.pdf>
- Air Diffusion Council Flexible Duct Performance & Installation Standards: http://a-actionhomeinspection.com/wp-content/uploads/pdfs/Flex_Ductwork_Installation.pdf
- Manual J, S and D Brochures: <http://www.acca.org/communities/community-home/librarydocuments/viewdocument?DocumentKey=da7e07a2-a854-4791-a4f8-c4edbe0374b2>

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Upcoming Webinars



April 25th, 1:00 to 3:05 PM

Third-party Residential Energy Code Verification
What Makes a Commercial Air Barrier? It's the Details!

May 30th, 1:00 to 3:05 PM

Applying the Energy Code to Existing Homes
COMcheck Case Study – Simple Commercial Building

June 27th, 1:00 to 3:05 PM

Residential Air Barriers
COMcheck for Existing Buildings

Register at www.masssave.com/energycode

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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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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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We Speak  Building



Energy Code
Technical Support
Program

Thanks!

Massachusetts Energy Code Technical Support Program



BLACKSTONE
GAS COMPANY



Columbia Gas
of Massachusetts
A Millcor Company

EVERSOURCE

Liberty Utilities

nationalgrid
HERE WITH YOU. HERE FOR YOU.

Unitil
GO ON FOR LIFE