IV. Mechanical Compliance Guide

Mechanical Requirements

You can use this guide to demonstrate that your commercial or high-rise residential building design complies with the *2002 Energy Conservation Construction Code of New York.* This guide covers the energy code requirements for mechanical systems and provides a simple prescriptive method (manual method) for demonstrating compliance.

Mechanical Compliance Options

This Mechanical Compliance Guide contains the energy code requirements for mechanical systems and equipment, and instructions on how to manually demonstrate and document that your proposed design complies with code requirements.

This guide has three major sections – Simple Systems, Complex Systems, and Water-Heating Systems. Generally, you can use the Simple Systems section with single-zone systems but need to use the Complex Systems section if your building contains any multiple-zone systems. The Simple Systems section is shorter and less technical and therefore is the preferred approach for any buildings that qualify. The brief Water-Heating Systems section provides code requirements for service water-heating systems for all types of commercial buildings.

The *COMcheck-EZ* software offers an alternative compliance method. The software uses a "wizard" approach that enables you to readily generate a checklist of mechanical requirements applicable to your building design. Refer to the *COMcheck-EZ* Software Compliance Guide for instructions on using the software method.

Demonstrating Compliance

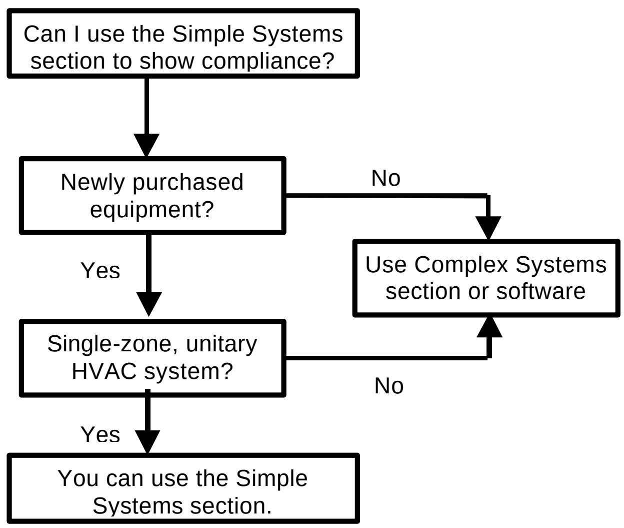
To demonstrate compliance, indicate on your project plans equipment efficiencies, system controls, outdoor-air ventilation rates, duct insulation levels, duct sealing, and water-heating components that comply. Complete a

Mechanical Compliance Certificate –either for simple or complex systems– provided with this guide and include it with the permit submittal materials.

Qualifying for Simple Systems Method

COMcheck-EZ provides a simple way to demonstrate compliance with energy code requirements. You can use this simple method if your design uses the following equipment types:

- cooling – new unitary-packaged, split-system or packaged terminal air conditioner or heat pump
- warm-air heating – new unitary-packaged, split-system or packaged terminal heat pump; new fuel-fired furnace
- hydronic heating – 2-pipe hot water radiators, baseboard heaters, fan coils, or other individual terminal heating units with new central boiler and no cooling system installed in the building



You cannot use the *Simple Systems* section with the following equipment types:

- packaged VAV reheat
- built-up VAV reheat
- built-up single-fan, dual-duct VAV
- built-up or packaged dual-fan, dual-duct VAV
- 4-pipe fan coil system with central plant
- hydronic heat pump with central plant
- other multiple-zone or built-up systems
- all other hydronic space-heating systems
- any combination of different types of allowed systems such as hydronic heating and unitary-packaged cooling.

To determine compliance for equipment types not covered in the *Simple Systems* section, refer to the *Complex Systems* section of this guide, the *COMcheck-EZ* software, or other compliance method acceptable to code officials.

Electric Resistance Space Heating

Single and muti-family buildings heating with electrical resistance units, including baseboard radiation, heat pump reheat coils, duct coils, boilers, domestic hot water heaters and coils in terminal units and air systems shall use table 502.2.4(10) or the software for envelope compliance.

Simple Systems

This section applies only to buildings that meet all of the qualifying criteria in the previous section *Qualifying for Simple Systems Method*.

To promote the use of energy-efficient mechanical systems and equipment in commercial and high-rise residential buildings, the energy code requires

- calculation of heating and cooling loads
- minimum equipment efficiency at peak- and (in some cases) part-load conditions
- acceptable levels of outdoor-air ventilation to ensure occupant comfort and health
- use of outside-air economizers for systems over 65,000 Btu per hour cooling capacity
- ducts that are insulated and sealed to minimize heating and cooling energy losses
- hydronic heating system features that reduce distribution losses and increase part-load efficiency
- specific HVAC controls.

Mechanical Equipment Efficiencies

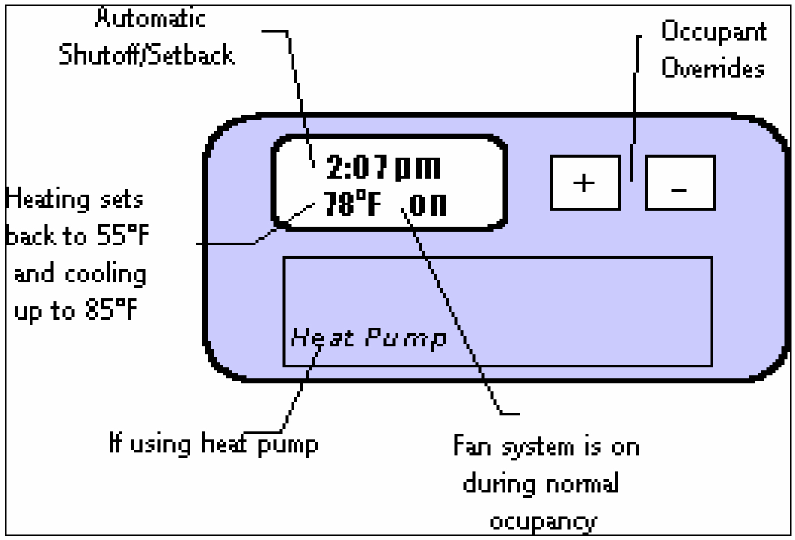
The *2002 Energy Conservation Construction Code of New York* requires that mechanical equipment meet minimum efficiency ratings. You need to indicate the proposed equipment efficiencies on the mechanical plans and project specifications. Heating and Cooling System Control Requirements

Thermostats

A thermostat is required in each zone to control heating and/or cooling. Thermostats must have the capability to automatically set back or shut down heating, cooling, and ventilation systems when appropriate. Thermostats must also have an accessible override so occupants can operate the system during off-hours. Heat pumps with supplementary heat must have thermostats specifically designed for heat pump operation; i.e. to use supplementary heat only when the heat pump operating alone is inadequate to meet the load.

A programmable thermostat must be used to meet these requirements. These thermostats are available for heating only, cooling only, heating and cooling, and heat pump systems. They can set back or shut down the system during nights and weekends. In addition, occupants can temporarily override the thermostat and it will return to the original schedule without reprogramming.

Thermostats that control the temperature in residences, hotel/motel guest rooms, or areas where heating and/or cooling systems must operate continuously do not require a setback or shutoff control.



Thermostat Requirements

Humidity Controls

When humidistats are installed, they must prevent the use of fossil fuel or electric power to achieve a humidity level below 60 percent when the system controlled is cooling, and above 30 percent when the system is heating.

Hydronic Heating Requirements

The requirements listed in this section apply to systems that provide heating only through the use of individually controlled radiators or fan-coils and are served by a central hot water boiler. The following components are required on zonal heating systems:

1. thermostats meeting requirements for each individual heating zone
2. pipe insulation - to reduce distribution and standby losses
3. variable-flow controls on the circulation pump or temperature reset controls for systems with capacities over 600,000 Btu per hour to increase efficiency during part-load operation.

For hydronic system part-load control requirements, refer to *Part-Load Control Requirements for Hydronic Systems* in the *Complex Systems* section.

Outdoor-Air Ventilation Requirements

Outdoor-air ventilation rates necessary to maintain indoor-air quality while minimizing energy use are continuously being debated. The concerns of designers and health professionals regarding indoor-air quality were considered in developing this guide, thus outdoor-air ventilation and control requirements are included. However, the designer is ultimately responsible for recognizing building features that may cause poor indoor-air quality. Adherence to requirements in this guide alone cannot ensure that good indoor-air quality will be maintained.

All enclosed spaces where people are expected to remain for extended periods of time must be continuously ventilated with outdoor air. A space can be ventilated naturally or mechanically. These spaces must be ventilated according to the applicable building or Mechanical Code of New York State.

In addition, spaces that may contain unusual sources of contaminants must be designed with enclosures to contain the contaminants. These spaces must also have local exhaust systems to directly vent the contaminants (see Chapter 5 of the *Mechanical Code of New York State*.)

Mechanical Ventilation

If your design includes mechanical ventilation, it must

- meet minimum ventilation rates
- meet provisions for operating the system at those rates
- include dampers to prevent air infiltration during periods of building non-use.

Minimum Outdoor-Air Requirements

Your design's heating and/or cooling system must supply the minimum-required outdoor air to a space (refer to *Mechanical Code of New York State* for required rates). A supply- and return-air system or an exhaust system must supply the outdoor air. Refer to Chapter 4 of the *Mechanical Code of New York State*.

Ventilation Controls

When the heating and/or cooling system is controlled by a thermostat with a fan On/Auto switch, the switch must be set to the On position. Outdoor air is then supplied to the building whenever the system is operating. If a thermostat with a built-in time-switch is used, the thermostat must be capable of setting back or shutting off the fan during periods of nonuse.

Some ventilation systems are designed to supply outdoor-air quantities exceeding minimum levels. These systems must also be capable of reducing outdoor-air flow to minimum levels. Devices such as return ducts, mechanically or automatically operated control dampers, or fan volume controls can be used to reduce air flow.

Shutoff Dampers

Outdoor-air supply and exhaust systems with design air flow rates greater than 3000 cubic feet per minute of outdoor air must have dampers that automatically close while the equipment is not operating. This requirement will mainly affect dedicated outdoor-air supply systems in paint shops, restaurants, and auditoriums. This requirement does not apply to automatic dampers mandated by health and life safety codes.

Natural Ventilation

Windows, doors, louvers, or other openings to outdoor air can provide natural ventilation to interior spaces. Refer to Section 402 of the *Mechanical Code of New York State* to find minimum area requirements for above- and below-grade openings, adjoining spaces, and spaces containing contaminants. The codes typically require that a free opening of at least 4% of the floor area be available for natural ventilation.

Question
What is the window area required to ventilate a 30 x 32-ft office?
Answer
The area of the opening must be (30 x 32 ft) x 4% = 38.4 sq ft The actual window area must be at least 76.8 sq ft if only half the window opens. This calculation is based on free area. With framing, the actual window area is approximately 80 sq ft.

Cooling with Outdoor Air Economizer Systems

Air economizer systems take advantage of favorable weather conditions to reduce mechanical cooling by introducing cooler outdoor air into a building. They may be required on packaged units greater than 65,000 Btu per hour cooling capacity. When properly installed and maintained, these systems can reduce mechanical cooling by up to 75%.

The code requires air economizers capable of delivering at least 100% of the supply air directly from outdoors.

Typical economizer controls include a two-stage thermostat and an economizer controller using dry-bulb temperature or enthalpy, or a combination of both. A control is also included to prevent ice from forming on cooling coils. This control arrangement allows outdoor-air cooling, mechanical cooling, or outdoor-air plus mechanical cooling—a feature known as “integrated control.” Field- and factory-installed economizers supplied by major equipment manufacturers must include integrated controls.

The code requires the use of integrated-control economizers for all systems. Exceptions to this requirement are

- cooling systems with a total cooling capacity less than 65,000 Btu per hour
- systems serving residential spaces, supermarkets, or hotel/motel guest rooms
- Systems with air or evaporatively cooled condensors and which serve spaces with open case refrigeration or that require equipment

in order to meet Section 403.3 of the *Mechanical Code of New York State*.

Shut-off Dampers

Outdoor air supply and exhaust ducts shall be provided with automatic means to reduce and shut off airflow.

Exceptions to this requirement are:

- Systems serving areas designed for continuous operation
- Individual systems with a maximum of 3,000 cfm airflow rate
- Systems with readily accessible manual dampers
- Where restricted by health and life safety codes.

Duct Requirements

Ducts must be properly insulated and sealed to reduce energy loss.

Insulation

All supply- and return-air ducts and plenums must be insulated with a minimum of R-5 insulation when located in unconditioned spaces (e.g., attics, crawl spaces, unheated basements, unheated garages) and with a minimum of R-8 when located outside the building envelope. When located within a building envelope assembly, the duct or plenum shall be separated from the building exterior or unconditioned spaces by a minimum of R-8 insulation.

Exceptions:

- when located within equipment
- exhaust-air ducts
- when the design temperature difference between the interior and exterior of the duct or plenum does not exceed 15°F (8°C).

Sealing

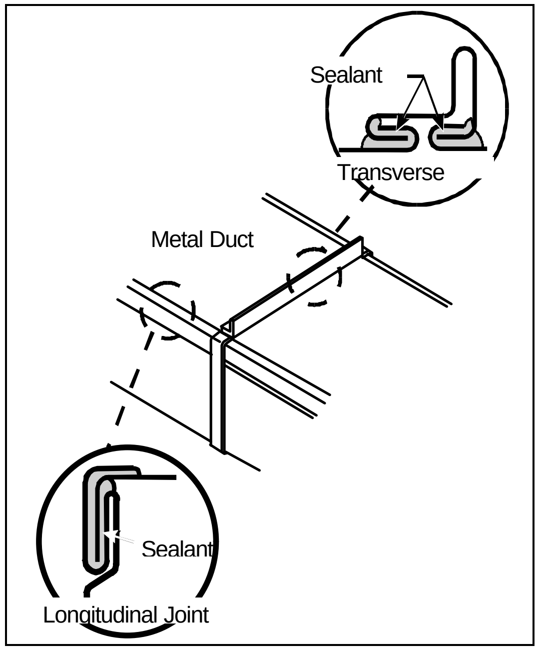
Ducts are sealed to ensure quantities of air are not lost before they are delivered to the space. Flexible and metal ducts are common in small- to medium-size commercial buildings.

Properly sealing plenums, air handlers, and ducts is the key to eliminating leaks. In duct systems, all joints, longitudinal and transverse seams, and connections must be securely fastened and sealed with welds, gaskets, mastics (adhesives), mastic-plus-embedded-fabric systems, or tapes. Duct mastic-plus-embedded-fabric is the preferred flexible sealant. Tapes and mastics used to seal duct work must be listed for their intended application.

Although the code does not require duct mastic, its use is strongly encouraged. Conventional duct tape must not be used except to seal the joints on duct access doors and air-handler panels.

Additionally, duct registers, grilles, and diffusers must be sealed to the gypsum board or other interior finish. Penetrations into the supply or return plenum (taps, takeoffs, and starting collars) and any structural cavities used for air plenums or ducts must also be sealed.

In the diagram, an exterior-duct sealant is used to seal both transverse and longitudinal seams. Pressure-sensitive tape (duct tape) cannot be used as the primary sealant.



Sealing Metal Duct Transverse Seams

Pipe Insulation Requirements

Pipe insulation requirements depend on the fluid type and nominal pipe diameter. The following table shows pipe insulation requirements based on an insulation thermal conductivity of 0.27 Btu·in/(h·ft^2·°F) [roughly R-4 per inch]:

Fluid	Pipe Diameter (in.)	
	Not greater than 1.5”	Greater than 1.5”
Steam	1.5”	3.0”
Hot Water	1.0”	2.0”
Chilled Water, Brine, Refrigerant	1.0”	1.5”

Insulation is not required with the following types of piping:

- factory-installed piping within HVAC equipment that has been tested and rated in accordance with a referenced test procedure to determine equipment efficiency
- piping conveying fluids having design operating temperatures between 55°F and 105°F
- piping conveying fluids that have not been heated or cooled through the use of fossil fuels or electric power

- runout piping no longer than 4 feet and no greater than 1 inch in diameter installed between the control valve and heating or cooling coil in an HVAC unit.

Complex Systems

This section is designed to provide a relatively simple process for demonstrating compliance with energy code requirements that apply to multi-zone HVAC systems. It is designed for use with any of the following system or equipment types:

- single-duct VAV distribution with zone reheat
- dual-duct VAV (either with a single supply fan or separate fans for heating and cooling ducts)
- constant-volume, single-zone with chilled water, hot water, or built-up direct expansion coils or fuel-fired furnaces
- three-duct, constant- or variable-volume air distribution
- 4-pipe fan coil
- hydronic heat pump
- all types of central plant equipment, including electric- and heat-operated water chillers, boilers, and central refrigeration compressors serving one or more direct-expansion cooling coils.

This section can also be used with the following system types, although they are covered more simply under the *Simple Systems* section:

- packaged air conditioners – new unitary-packaged, split-system or packaged terminal air conditioner or heat pump
- packaged warm-air furnaces – new unitary-packaged, split-system or packaged terminal heat pump; new fuel-fired
- You can use *COMcheck-EZ* for either constant volume multi-zone systems with reheat or constant volume, dual duct systems only if all thermostatic control zones served by the system meet one of the exceptions to the requirement for VAV systems (see *Multiple-Zone System Requirements*)

To promote the use of energy-efficient systems and equipment in commercial and high-rise residential buildings, the energy code requires:

- calculation of heating and cooling loads
- minimum equipment efficiency at peak- and part-load conditions
- controls that maximize air and hydronic system efficiency at part-load conditions
- controls that eliminate or minimize system operation during periods of nonuse
- water or air economizers on most systems
- minimum duct and pipe insulation levels and duct sealing measures
- efficient technologies and control strategies for variable-flow and multiple-zone systems

- acceptable levels of outdoor-air ventilation
- Systems tested and balanced with operating and maintenance manuals provided.

Equipment Efficiency Requirements

Heating and cooling equipment must meet the minimum efficiencies listed in the tables provided at the end of this guide. Equipment types not listed in these tables have no minimum efficiency requirements.

Federal manufacturing standards cover many of the equipment types listed in the tables, as is clearly noted. You can assume new equipment covered by these standards meet minimum efficiency requirements. Construction documents must include rated efficiencies for noncovered equipment and it is advisable to include ratings for all specified equipment. Enforcing jurisdictions may require that documentation, such as manufacturers' literature, be submitted in support of efficiencies reported in the construction documents.

If you use the software compliance method or some other methods, you may be able to trade off some insulation requirements if you specify higher efficiency equipment.

Field-Assembled Equipment Requirements

Some complex systems use combinations of components to perform a cooling or heating function. For example, the system uses a separate heat exchanger and compressor for chilling water instead of a package water chiller. You must show that these systems meet the same requirements as the equipment listed in the tables for the comparable equipment type. Total energy input to the equipment must consider all the energy use of all components and accessories such as compressors, internal circulating pumps, condenser-fans, integral cooling water pumps, purge devices, crank case heaters, and controls. An enforcing jurisdiction may require that the registered engineer responsible for equipment specification stamp, sign, and date calculations.

Equipment Sizing

To determine the required size of heating and cooling equipment, designers must calculate the maximum heating and cooling loads for a building in accordance with the *1999 ASHRAE Handbook – Fundamentals* and ensure that heating and cooling equipment is sized no larger than needed to meet those loads. The enforcing jurisdiction may require that the registered engineer responsible for equipment sizing stamp, sign, and date calculations and supporting documentation.

Some building owners want additional equipment (for example, an additional chiller of the same capacity) in case the primary equipment goes out of service. Standby equipment is allowed as long as it is separate equipment and is controlled to be always off when the primary equipment is operating.

Multiple units of the same equipment type with a combined capacity in excess of the calculated loads are also allowed if they are controlled to operate in sequence. In this case, additional units must be controlled to only operate as the load increases and cannot be controlled to turn on all at the same time.

System Control Requirements

Temperature Controls

Each thermostatic control zone must be equipped with a thermostat or other device that controls heating and cooling to the zone and responds to environmental conditions within the controlled zone.

Exception: Perimeter Systems

Some complex mechanical systems have a separate system to handle envelope loads (mainly heat loss through the walls and windows and heat gain through windows), and serve interior spaces with a separate system. Individual zone controls are not required for perimeter systems if the controls for the perimeter system meet the following conditions:

- at least one temperature control must be installed for each perimeter area with exterior walls facing one orientation for 50 contiguous feet or more
- the thermostatic system control must be located within the space being served by the system.

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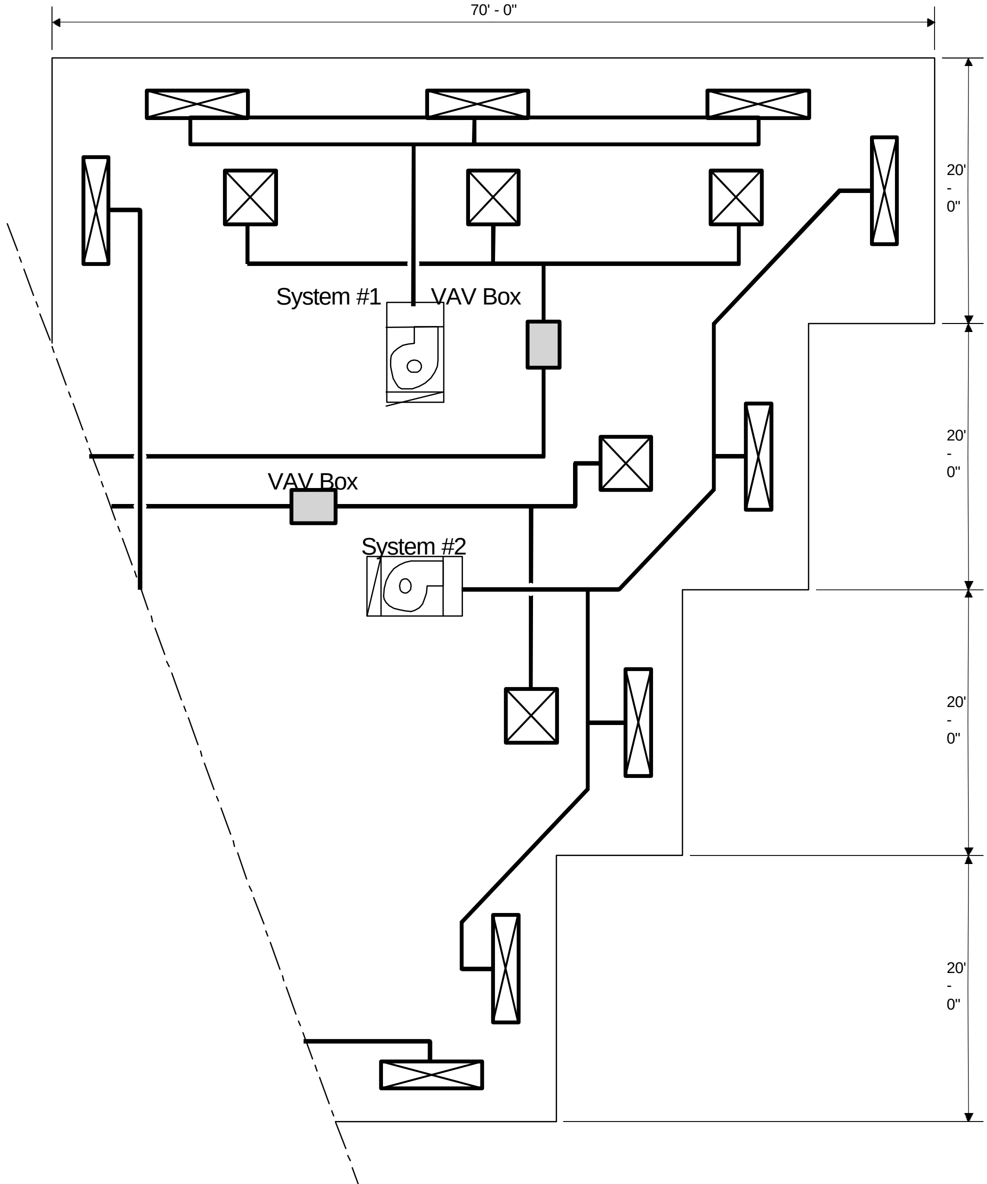
Independent Perimeter Systems



System #1: At least one temperature control within the controlled space must be installed since the contiguous length of the building facade faces one orientation and is greater than 50 feet in length
System #2: All supply air outlets may be controlled with one controller within the space. Though the building facades of the spaces served by this system face different orientations, none is 50 feet or more in length.

Thermostat Deadband Requirements

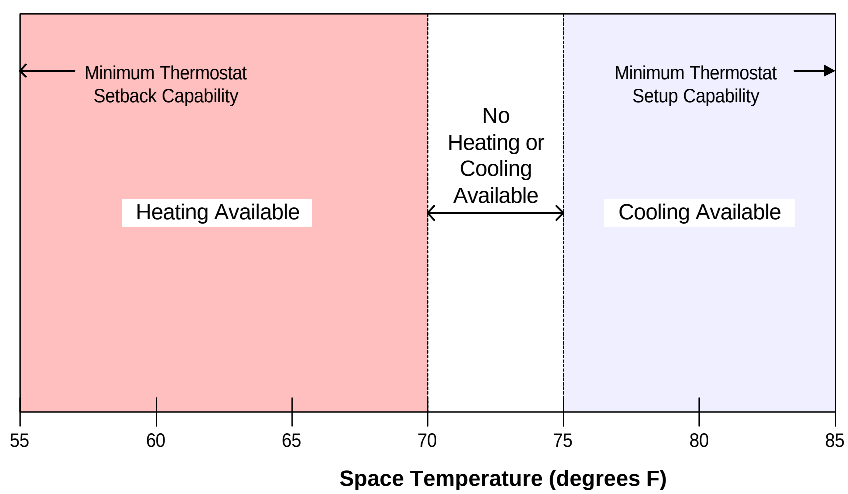
Thermostats that control both heating and cooling must be capable of having a "deadband" or range of temperature of at least 5°F where no heating and cooling is available. (Exception: thermostats requiring manual changeover between heating and cooling modes.)

Automatic System Controls During Periods of Non-Use

Single-zone systems and each zone served by multiple-zone systems must have controls that automatically reduce heating and cooling use during periods of non-use. Automatic controls can be time clocks that shut down systems or zones, time-controlled automatic setback controls, or occupancy sensors. Time controls and automatic time clocks must

- be able to start and stop systems, or turn on and shut off the supply of heating, cooling and ventilation to each zone, for seven different day schedules per week
- retain programmed set points and time settings for at least 10 hours during power outages
- include or be installed in conjunction with a manual override that allows occupants to turn heating and cooling on for up to two hours during periods when the heating and cooling would otherwise be automatically off.

Thermostatic controls must be able to automatically set up the cooling set point to at least 85°F and set back the heating set point to a temperature no greater than 55°F.



Typical Thermostat Deadband and Required Setback/Setup Capabilities

Outside-Air Shutoff Controls

Even when a building is unoccupied and ventilation fans are not operating, outside air entering the building can significantly change the indoor temperature and humidity. This change in temperature and humidity can cause unnecessary energy use when the building is reoccupied and the mechanical systems are restarted. All supply- and exhaust-air systems must include a way to automatically close outside-air intakes when mechanical ventilation fans shut off. In smaller fan systems (less than 5,000 cfm), gravity dampers or dampers weighted to close when air is not moving through them are common. On larger systems, electric motors or pneumatic actuators are typically used to open and close outside-air dampers. Systems with total air volume of 3,000 cfm and less are not required to have automatic outside-air shutoff controls.

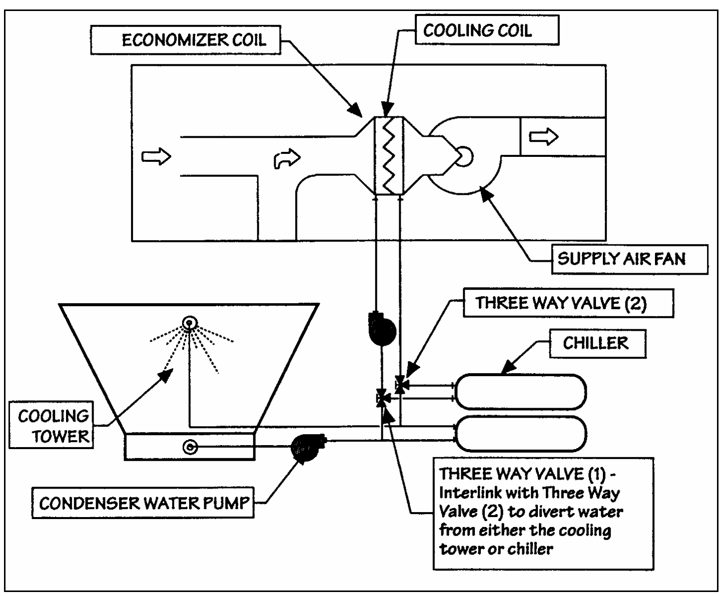
Cooling with Outdoor Air (Economizers)

All systems with nominal cooling capacities greater than 65,000 Btu per hour must be equipped with an air economizer, or meet one of the economizer exceptions described in the Simple Systems section. Alternatively, complex mechanical systems may be equipped with water economizers designed to meet the design cooling load calculated as follows:

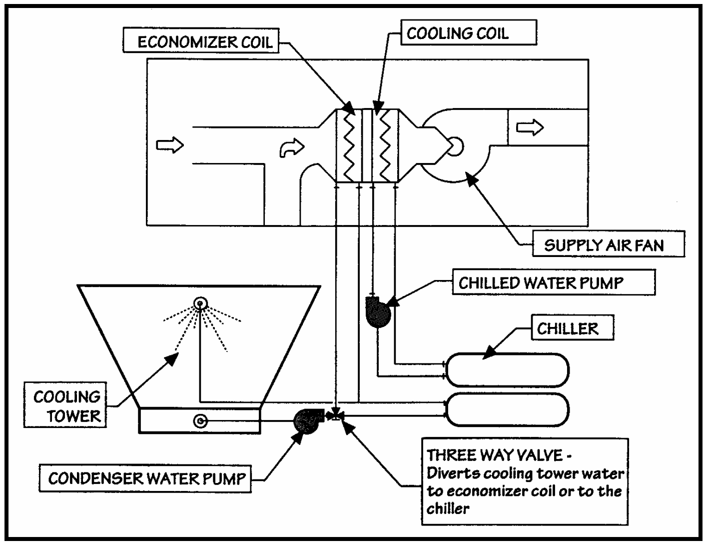
- cooling loads calculated according to the Equipment Sizing section
- water economizer outdoor operation temperatures of 50°F dry-bulb and 45°F wet-bulb.

The enforcing jurisdiction may require that the engineer responsible for system design authenticate and submit water economizer designs and supporting documentation.

The following figures show the most common types of water economizer systems:



Direct Water Economizer System



Indirect Water Economizer System

Variable-Flow Fans

Fans capable of varying their airflow are common on systems serving multiple thermostatic control zones and are sometimes used in exhaust applications. These fans must use one of the following airflow control methods:

- a mechanical adjustable-speed drive, which usually varies air flow by varying the diameter of one of the pulleys in the motor/belt drive system for the fan
- an electrical adjustable-speed drive, which uses electronic controls to vary the speed of the fan motor
- a vane-axial (or propeller style) fan with variable-pitch blades
- other variable-flow technologies that limit fan power to 30% of peak design fan power when air flow is 50% of design flow rate and static pressure is one-third of peak design static pressure, based on manufacturer's fan data.

Hydronic System Requirements

Systems with hydronic heating for both heating and cooling must have separate supply and return lines for hot and chilled water. Systems shall not have the capability to supply hot and chilled water concurrently to any terminal unit.

Exceptions:

(a) Zones where special humidity levels are required to satisfy process needs.

(b) Two-Pipe Changeover System. Systems that use a common distribution system to supply both heated and chilled water are acceptable provided all of the following are met:

a. The system is designed to allow a deadband between changeover from one mode to the other of at least 15°F outside air temperature.

b. The system is designed to operate and is provided with controls that will allow operation in one mode for at least four hours before changing over to the other mode.

c. Reset controls are provided that allow heating and cooling supply temperatures at the changeover point to be no more than 30°F apart.

Part-Load Control Requirements for Hydronic Systems

Most systems operate at peak-load only during a small portion of the heating and cooling seasons. The energy code requires one of the following approaches for increasing hydronic heating and cooling system efficiency during part-load operation:

1. Water Temperature Reset – Using this approach, controls must be installed to decrease the temperature of the water leaving the heating plant as the overall demand for heating decreases, and increase the temperature of the water leaving the cooling plant as the overall demand for cooling decreases. Controls must be capable of decreasing (or increasing) water temperature by at least 25% of the difference between the design supply and return water temperatures.

Question
What is the reset requirement for a hot water distribution system if the design water temperature is 180°F and the design return temperature is 150°F?
Answer
The minimum amount of reset is: (180°F – 150°F) x 25% = 7.5°F Therefore, controls must be able to reset the water temperature to: **180°F – 7.5°F = 172.5°F**

2. Variable Flow – Using this approach, controls must be installed that will reduce the flow of water as the overall demand for heating (or cooling) decreases. Acceptable methods for reducing flow are a) variable-frequency drives on pumps, which vary the speed of the pump; b) multiple, staged pumps, which vary the number of pumps used to circulate water; or c) control valves, which modulate to vary the flow of water.

Heat Rejection Equipment Fan Speed Control

Each fan powered by a motor of 7.5 hp (5.6 kW) or larger shall have the capability to operate that fan at two-thirds of full speed or less, and shall have controls that automatically change the fan speed to control the leaving fluid temperature or condensing temperature/pressure of the heat rejection device.

> **Exception:** Heat rejection devices included as an integral part of the equipment listed in Tables 803.2.2(1) through 803.2.2(3) and 803.3.2(2). These tables are included at the end of this chapter.

Multiple-Zone System Requirements

Most larger buildings have HVAC systems that can heat and cool multiple independently controlled zones at the same time. Commonly called multiple-zone systems, these systems typically will reheat cool air, recool warm air, or mix warm and cool air to meet individual zone temperature requirements. Multiple-zone systems must have VAV controls capable of reducing the supply of warm (or cool) air to any zone before reheating, recooling, or mixing warm and cool air streams occurs.

Under some conditions, simultaneous heating and cooling is allowed without the need for individual VAV controls at the zone. The six exceptions below permit the use of constant-volume reheating, recooling, or mixing for individual zones. Except for Exception 6, these exceptions are not intended to allow the installation of constant-volume, multiple-zone systems, but rather to allow individual zones to have constant volume with reheating, recooling, or mixing on an otherwise complying VAV system.

Exception 1 – Zone Pressurization Requirements

If VAV operation will create unacceptable pressure relationships between a sensitive zone and other zones, simultaneous heating and cooling is allowed without VAV, but only for the sensitive zone.

Exception 2 – Site-Recovered or Site Solar Energy

Constant volume with reheating or mixing is allowed if 75% or more of energy for reheat or warm-air mixing is from any of the following sources:

- site-recovered energy such as heat recovery coils on an exhaust-air system or water chiller condenser
- site-generated solar energy such as solar water-heating collectors or photovoltaic panels.

Exception 3 – Special Humidity Requirements

In zones where specific humidity levels must be maintained for noncomfort purposes, simultaneous heating or cooling is allowed without VAV operation. Examples include areas of museums where sensitive materials are displayed or stored, or areas for manufacturing processes where precise humidity ranges are necessary. In these cases, the exception applies to the special zone and not to the entire system.

Exception 4 – Less than 300 cfm Zone Supply Air

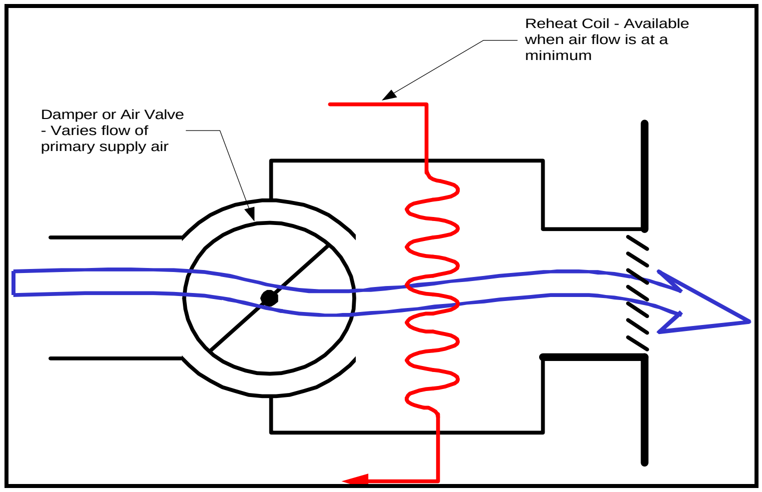
If the supply-air quantity to a zone is less than 300 cfm, simultaneous heating or cooling is allowed without VAV operation. This exception allows reheat to be used for small subzones of a larger zone. This exception is available only with air-handling systems serving multiple zones. It cannot be used to permit constant-volume, single-zone systems with subzone reheat.

Exception 5 – Ventilation Requirements

If the *Mechanical Code of New York State* requires that 100% outside air be supplied to a zone. VAV controls are not required for zones with 100% outside-air requirements.

Exception 6 – Sequencing Heating and Cooling to the Zone

VAV controls are not required if zone and system controls can sequence the supply of heating and cooling energy to the zone so that simultaneous heating and cooling never occurs. For example, a three-duct air distribution system consists of separate ducts for return air, cool air, and warm air. Zone controls will mix warm air with return air and cool air with return air but never warm air with cool air.



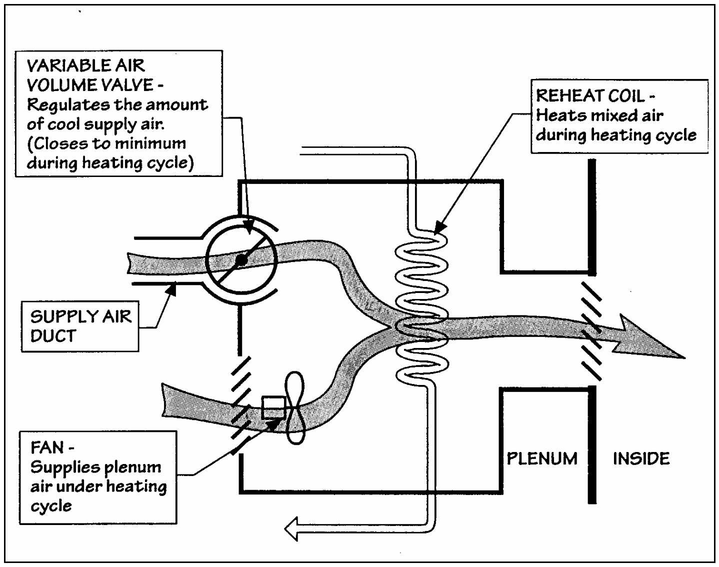
Nonfan-Powered VAV Box

Other Requirements for Multi-Zone Systems

In addition to the requirement for VAV zone controls, multi-zone systems must meet applicable requirements described below, depending on the distribution system design and the total number of supply fans.

Single-Duct VAV Systems

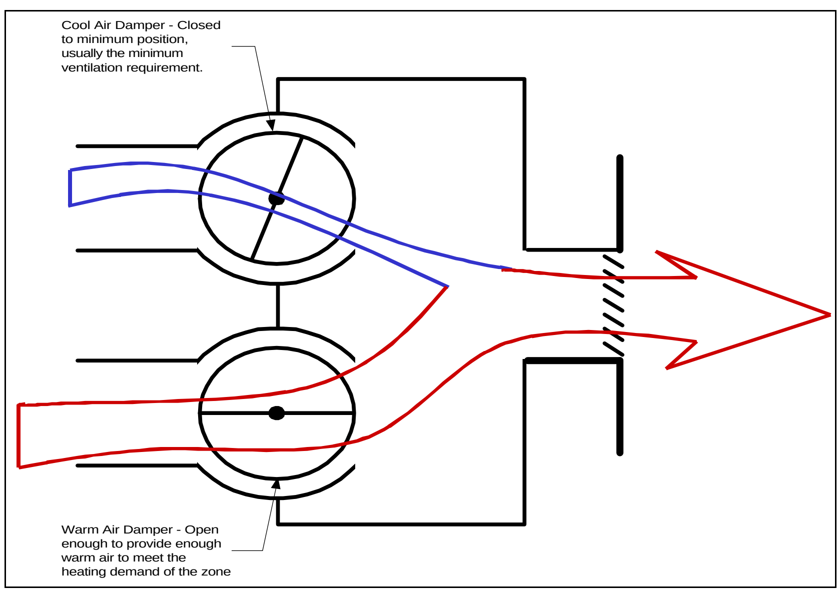
Single-duct VAV systems use a single supply-air duct with branches to individual zones. Thermostatically controlled terminal units are then used to vary the flow of air to the zone, and reheat or recool the air if necessary to meet the environmental control requirements for a zone. Single-duct VAV terminal units must be capable of reducing the supply of primary supply air to the zone to a minimum before reheating or recooling can occur. Single-duct VAV terminal units may also be equipped with a fan to draw air from a return-air plenum to for additional heat. The figures below show fan- and nonfan-powered VAV terminal units and their required features.



Fan-Power VAV Box

Dual-Duct VAV Systems

Dual-duct systems provide two separate supply air streams–cool air and warm air–that are mixed in each terminal unit and supplied to the zone as a single air stream. The system can have a single fan for both supply-air ducts or a separate fan for each duct. Dual-duct zone terminal units must be capable of reducing the air supply from one duct to a minimum prior to mixing with the other duct. These units require a damper or other way to reduce the airflow, as well as controls that prevent mixing with the other air stream until the minimum is reached. The figure below provides a schematic of a dual-duct terminal unit.



Dual-Duct VAV Mixing Box in Heating Mode

Dual-Duct and Mixing Systems with One Fan, Economizer Requirements

Single-fan, dual-duct systems use a single supply fan to blow air over two separate coils–one for heating and one for cooling. If an air economizer is used, outside air rather than return air is passed through the heating coil, thereby increasing energy use for heating. To avoid this additional energy use, dual-duct and other mixing systems (such as three-duct systems) with single supply fans cannot be equipped with air economizers. With no air economizer, only return air and minimum outside ventilation air need to be heated.

To meet economizer requirements with these systems, a water economizer must be installed. If the water economizer uses an additional cooling coil in the supply-air stream, then this coil must be installed in the system's cool-air duct and not in the return- or mixed-air portion of the ductwork.

Ventilation Requirements

Refer to the *Simple Systems* section for minimum outside-air ventilation requirements.

Duct Requirements

Refer to the *Simple Systems Duct Requirements* section for duct insulation, sealing, and installation requirements. In addition, all ducts designed to operate at static pressures in excess of 3 inches of water column must be leak-tested in accordance with methods published by the Sheet Metal and Air Conditioning Contractors of North America (SMACNA). A report and certificate must be submitted demonstrating that representative sections totaling at least 25% of the duct area have been tested and that all tested sections meet the duct-sealing requirements.

Leak tests and reports must demonstrate that the duct system meets the following criterion:

$$F < 6 \times P^{0.65}$$

where F = the measured leakage rate in cfm per 100 square feet of duct surface

P = the static pressure used in the test.

0.65 = the exponent (or power) to which the static pressure is raised in this equation

For example, the maximum leakage rate for a duct section operating at 4 inches water column static is

$6 \times 4^{0.65}$ or 15 cfm per 100 square feet of duct surface area.

Pipe Insulation Requirements

Pipe insulation requirements depend on the fluid type and nominal pipe diameter. The following table shows pipe insulation requirements based on an insulation thermal conductivity of 0.27 Btu·in/(h·ft^2·°F) [roughly R-4 per inch]:

Fluid	Pipe Diameter (in.)	
	not greater than 1.5”	greater than 1.5”
Steam	1.5”	3.0”
Hot Water	1.0”	2.0”
Chilled Water, Brine, Refrigerant	1.0”	1.5”

Insulation is not required with the following types of piping:

- factory-installed piping within HVAC equipment that has been tested and rated in accordance with a referenced test procedure to determine equipment efficiency
- piping conveying fluids having design operating temperatures between 55°F and 105°F
- piping conveying fluids that have not been heated or cooled through the use of fossil fuels or electric power
- runout piping no longer than 4 feet and no greater than 1 inch in diameter installed between the control valve and heating or cooling coil in an HVAC unit.

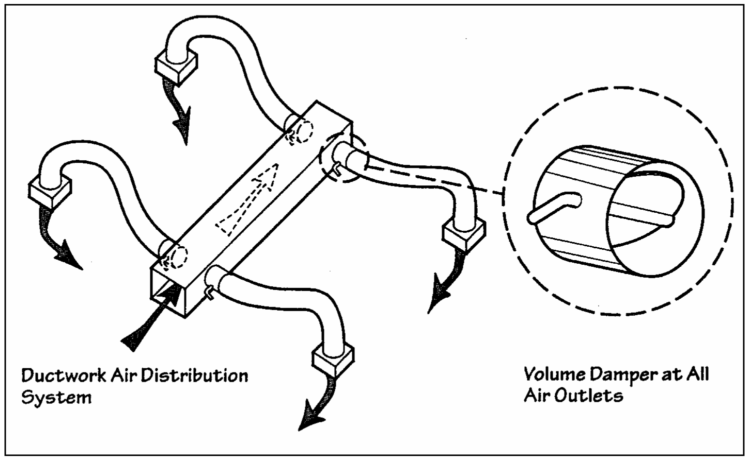
HVAC System Completion

Prior to occupancy, the following checks should be performed to insure proper system operation.

Air System Balancing

Proper system design and equipment selection is essential for long-term functionality and energy efficiency of mechanical systems. All systems need some type of verification in the field (both at start-up and periodically throughout the life of the building) to ensure they are operating as intended.

To facilitate field verification, the energy code requires that duct systems be equipped for easy testing and balancing after installation. Each supply-air outlet and zone-air terminal device must be equipped with balancing dampers, air valves, or other means for balancing. Balancing dampers that are integral to supply-air diffusers are acceptable for supply-air outlets.



Air Balancing Device

Hydronic Systems Balancing

To facilitate proper balancing and long-term efficient operation of hydronic systems, all hydronic terminal devices must be equipped with balancing valves or other means of hydronic system balancing.

Manuals and System Documentation

The code requires building plans, specifications, or other construction documents to require the mechanical contractor to provide an operating and maintenance manual to the building owner. This manual must include at least the following information about the design and intended operation of all mechanical systems in the building:

- equipment capacity (input and output) and required maintenance items and their required service interval
- equipment operation and maintenance manuals
- HVAC system control maintenance and calibration information, including
  - wiring diagrams
  - schematics
  - control sequence descriptions.

  Desired or field-determined set points must be permanently recorded on control drawings, at control devices, or, for digital control systems, in programming comments.
- a complete narrative of how each system is intended to operate.

Fireplaces

Fireplaces (solid fuel type) shall be installed with tight fitting noncombustible fireplace doors to control infiltration losses in the construction type listed here:

(a) New masonry fireplaces or fireplace units designed to allow an open burn.

(b) Whenever a decorative appliance (ANSI Standard Z21.60 gas-log style unit) is installed in an existing vented solid fuel fireplace that is also required to have a permanent free opening.

(c) See Section 102.7(3). Fireplace (solid fuel type) units shall be provided with a source of combustion air, ducted from the outdoors, of sufficient quantity to support combustion. This source shall be equipped with a damper capable of being fully closed.

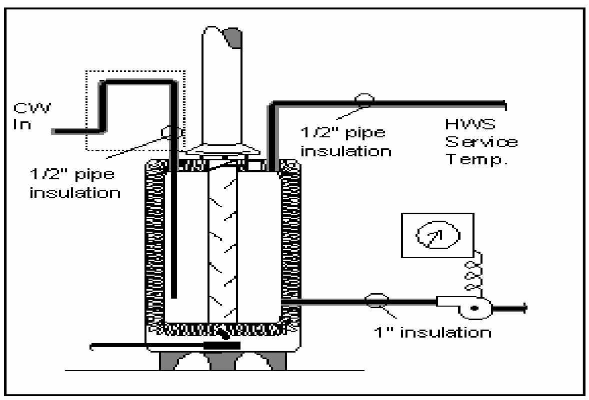
(A blank compliance certificate for complex systems can be found at the end of this Mechanical Guide.)

Water-Heating Systems

This section contains code requirements for service water-heating systems and equipment, and instructions on how to manually demonstrate that your proposed design complies with these requirements.

The requirements listed in this section apply to service and domestic water-heating systems. They do not apply to systems used for comfort heating or to systems designed to meet manufacturing, industrial, or commercial process requirements. The following components are required on water-heating systems (components shown in the following diagram by number):

1. heat traps - to reduce standby losses
2. pipe insulation - to reduce distribution and standby losses
3. circulation loop temperature control - to reduce distribution losses.



Water-Heating System Requirements

Equipment Efficiency Requirements

Heating and cooling equipment must meet the minimum efficiencies listed in the table provided at the end of this guide. Equipment not listed in these tables has no minimum efficiency requirements.

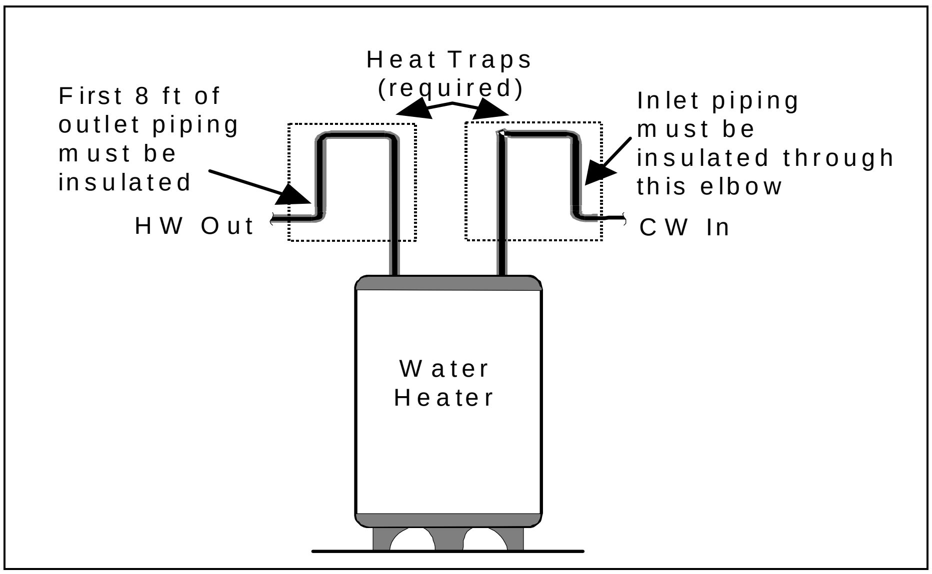
Federal manufacturing standards cover all of the equipment types listed in the table. Therefore, you can assume that any new service water-heating equipment will meet minimum efficiency requirements. Any reused equipment may not meet these requirements. Construction documents should include efficiency ratings for all service water-heating equipment.

Heat Traps

Heat traps stop hot water from rising into the distribution pipes and forming a natural convection loop.

Heat traps are required in the inlet and outlet piping of noncirculating water heaters. Some water-heating equipment has integral factory-installed heat traps. For equipment without integral factory-installed heat traps, heat traps must be purchased and installed in the inlet and outlet connections or field-fabricated by creating a loop or inverted U-shaped arrangement of the inlet and outlet piping.

Heat traps are not required on circulating systems.



Field-Fabricated Heat Traps

Pipe Insulation

The following pipe insulation levels are required:

- 1 in. on circulating water-heating systems
- ½ in. on the first 8 feet of outlet piping from any constant-temperature noncirculating storage system
- ½ in. on the inlet piping between the storage tank and a heat trap in a noncirculating storage system.

Circulation Loop Controls

Automatic time-switch controls must be installed to shut down the pump on circulating water-heating systems during periods of nonuse.

Demonstrating Compliance

To demonstrate compliance, indicate on your project plans the equipment efficiencies, system controls, and other water-heating components that comply. Also, fill in applicable items under *Water Heating Systems* on the *Simple Systems Certificate*. Blank copies of these certificates appear at the end of this chapter.

Completing Mechanical Compliance Certificate for Simple or Complex Systems

Blank forms are included at the end of this chapter. For each project fill out a blank certificate and check off all information in the boxes provided on the form. Enter “NA” if a particular requirement is not applicable; submit the completed certificate to the code official with the permit application package. The process for filling in the mechanical compliance certificate for complex systems is very similar to that for simple systems.

Simple Mechanical Compliance Certificate for the 2002 ECCCNYS

ALL INFORMATION MUST BE FILLED IN - PRINT CLEARLY

Section 1 - Project Information

Project Name		Permit #
Address		Date
Owner/Agent	Telephone	Checked By
Documentation Author	Telephone	Date *For Department Use Only*

Section 2 - General Information

Building Floor Area ____________ sq ft.

Project Description: ? New Construction ? Addition ? Alteration ? Unconditioned Shell

Section 3 - Requirements Checklist

	Check Items	Notes
Equipment Efficiency		
• Cooling Minimum EER: _________ Proposed EER: _________		
• Minimum Heating Efficiency: ____________		
• Proposed Heating Efficiency: ____________		
(Electric resistance heat is not allowed for most applications)		
Heating and Cooling System Controls		
• One solid-state setback thermostat with occupant override per zone	☐	
• Note Exceptions: • residences • hotel/motel guest rooms • areas that operate continuously		
• Humidity control set points	☐	
• Hydronic system controls	☐	
Outdoor-Air Ventilation		
• Outdoor air provided to each space (choose one method)		
• (a) air intake on mechanical system **-or-**	☐	
• (b) operable openings to outdoor air _____ sq ft.	☐	
• Shutoff dampers in restaurant make-up air systems	☐	
Cooling With Outdoor Air		
• Air economizer on systems $\geq$ 65,000 Btu/h	☐	
Shutoff Dampers		
• Automatic dampers on outdoor air supply and exhaust ducts > 3,000 cfm which are not designed for continuous operation	☐	
Duct Construction		
• Duct insulation meets minimum R-values	☐	
• Ducts in unconditioned spaces R-value __________ R-5 min		
• Ducts outside the building R-value __________ R-8 min		
• Ducts sealed	☐	
• Transverse joints on metal ducts are sealed	☐	
• All other ducts mechanically or otherwise sealed (no duct tape as primary sealant)	☐	
Hydronic Heating Systems		
• Pipe insulation: • Min. thickness required: ____ inches • Min. thickness proposed: ____ inches		
• Part-load efficiency method: (temp reset / variable flow) (*circle one*)		
Water-Heating Systems		
(Electric DHW = 5 kW input maximum)		
• Heat traps in inlet/outlet fittings	☐	
• Pipe insulation on inlet/outlet pipes _____ in. thickness		
• Recirculating System: (Y / N) (*circle one)*		
• Pipes insulated ____ in. thickness		
• Automatic time-switch control	☐	

Section 4 - Compliance Statement

The proposed mechanical design represented in these documents is consistent with the building plans, specifications, and other calculations submitted with this permit application. The proposed mechanical system has been designed to meet the 2002 ECCCNYS

Owner/Owner Representative - Name	Signature	Date

Mechanical Compliance Certificate for Complex Systems for the 2002 ECCCNYS

ALL INFORMATION MUST BE FILLED IN - PRINT CLEARLY

Section 1 - Project Information

Project Name		Permit #
Address		Date
Owner/Agent	Telephone	Checked By
Documentation Author	Telephone	Date *For Department Use Only*

Section 2 - General Information

Building Floor Area ____________ sq ft.

Project Description: ? New Construction ? Addition ? Alteration ? Unconditioned Shell

Section 3 - Requirements Checklist

	Check Items	Notes
Load Calculations		
• Load Calculations per 1997 ASHRAE Fundamentals	☐	
• Capacities shown on plans	☐	
Equipment Efficiency		
• Cooling Minimum EER: _________ Proposed EER: _________		
• Minimum Heating Efficiency: _____________		
• Proposed Heating Efficiency: _____________		
(Electric resistance heat is not allowed for most applications)		
HVAC System Controls		
• Minimum one temperature control device per zone	☐	
• Minimum thermostat capabilities:		
- Minimum 5º F deadband	☐	
- Setback/setup capability to 55º F (htg.) & 85º F (clg.)	☐	
- 7-day clock, 2-hr occupant override, 10-hr backup	☐	
Note Exceptions such as: • multifamily residential		
• hotel/motel guest rooms		
• areas that operate continuously		
Outdoor-Air Ventilation		
• In accordance with Chapter 4 of the IMC	☐	
• Automatic shutoff dampers on supply and exhaust systems with airflow >3,000 cfm	☐	
Economizers		
• Economizers on systems $\geq$ 65,000 Btu/h	☐	
Exceptions: supermarkets, residential, hotel guest rooms		
Variable Air Volume Fan Control		
• Systems serving more than one zone are VAV	☐	
Exceptions: - special pressurization relationships		
- 75% energy recovery		
- special humidity requirements		
- zone supply <300 cfm & 10% of total fan supply		
- where reheated/recooled air < min OSA req.		
- sequential ctrls that prevent reheat/recool		
• VAV fans with motors $\geq$ 25 hp:		
- have mech. or elec. variable speed drive(s) or	☐	
- are vane-axial fans with variable pitch blades or	☐	
- have other controls that reduce motor demand to 30% design kW at 50% design flow (calculations required)	☐	
• Controls are capable of resetting supply air temp (SAT) by 25% of (SAT - room temp) difference	☐	
• Single-duct VAV terminals are capable of reducing primary air before reheating	☐	
• Dual-duct VAV mixing boxes are installed to minimize mixing	☐	
Hydronic Systems Control		
• Separate hot and cold water supplies and returns	☐	
• No capability for concurrent hot and chilled water supply to terminals	☐	
Exceptions: - zones with special humidity requirements		
- Two-pipe changeover system meeting provisions of Vermont amendments		

Mechanical Compliance Certificate for Complex Systems for the 2002 ECCC of NYS (Cont'd)

Section 3 - Requirements Checklist

Requirement	Check Items	Notes
Hydronic Systems Control (cont'd)		
• Hydronic systems $\geq$ 600 kBtu/h have:		
- reset controls for supply water temperature or	☐	
- mechanical or electrical adjustable-speed pump drive(s) or	☐	
- multiple-stage pumps or	☐	
- other system controls that reduce pump flow by at least 50% based on load (calculations required)	☐	
Heat Rejection Equipment Fan Speed Control		
• Fans $\geq$ 7.5 hp must have speed control	☐	
Exception: Heat rejection devices included as an integral part of the equipment listed in Tables 803.3.2(1) through 803.3.2(4).		
Exhaust Air Energy Recovery		
• Fan systems $\geq$ 5,000 cfm with minimum OA supply $\geq$ 70% must have energy recovery system	☐	
Exceptions:		
- systems exhausting toxic fumes		
- type 1 Commercial kitchen hoods		
- where largest exhaust source <75% of design OA		
- systems requiring dehumidification		
- systems employing CO_2 control		
Exhaust Hoods		
• Kitchen hoods >5,000 cfm must use $\geq$ 50% of makeup air from unconditioned source	☐	
• Fume hood systems with exhaust rate >15,000 cfm must include one of the following:		
1. Variable air volume exhaust and supply system	☐	
2. Direct makeup air supply $\geq$ 75% exhaust rate	☐	
3. Heat recovery systems to precondition makeup air	☐	
Fireplaces		
• Fireplaces must be installed with tight-fitting fireplace doors to control infiltration losses	☐	
Duct Construction		
• Duct insulation meets minimum R-values	☐	
- Ducts in unconditioned spaces R-value _______ (R-5 min.)		
- Ducts outside the building R-value _______ (R-3 min.)		
• Ducts sealed	☐	
- joints and seams on ductwork fastened and sealed per UL 181A or B (no duct tape as primary sealant)	☐	
- systems with $\geq$ 3" wg sealed in accordance with SMACNA Leakage Class (CL) < 6.0	☐	
Hydronic Heating Systems		
• Pipe insulation: • Min. thickness required: _____ inches		
• Min. thickness proposed: _____ inches		
• Part-load efficiency method: (temp reset / variable flow) (*circle one*)		
Water-Heating Systems		
(Electric DHW = 5 kW input maximum)		
• Heat traps in inlet/outlet fittings	☐	
• Pipe insulation on inlet/outlet pipes ____ in. thickness	☐	
• Recirculating System: (Y / N) (*circle one)*		
- Pipes insulated ____ in. thickness	☐	
- Automatic time-switch control	☐	
HVAC System Completion		
• Balancing devices in accordance with IMC 603.15	☐	
• Balancing and pressure test connections on all hydronic terminal devices	☐	
• O & M manual(s) provided to building owner	☐	

Section 4 - Compliance Statement

The proposed mechanical design represented in these documents is consistent with the building plans, specifications, and other calculations submitted with this permit application. The proposed mechanical system has been designed to meet the 2002 ECCCNYS

Owner/Owner Representative - Name	Signature	Date

APENDIX A: Tables for Energy Efficient Commercial Construction

TABLE 803.2.2 (1)
UNITARY AIR CONDITIONERS AND CONDENSING UNITS, ELECTRICALLY OPERATED, MINIMUM EFFICIENCY REQUIREMENTS

Equipment Type	Size Category	Sub-Category or Rating Condition	Minimum Efficiency[b]	Test Procedure[a]
Air Conditioners, Air Cooled	< 65,000 Btu/h[d]	Split System	10.0 SEER	ARI 210/240
		Single Package	9.7 SEER	
	≥65,000 Btu/h and < 135,000 Btu/h	Split System and Single Package	10.3 EER[c]	
	≥135,000 Btu/h and < 240,000 Btu/h	Split System and Single Package	9.7 EER[c]	ARI 340/360
	≥ 240,000 Btu/h and <760,000 Btu/h	Split System and Single Package	9.5 EER[c] 9.7 IPLV[c]	
	≥760,000 Btu/h	Split System and Single Package	9.2 EER[c] 9.4 IPLV[c]	
Air Conditioners, Water and Evaporatively Cooled	< 65,000 Btu/h	Split System and Single Package	12.1 EER	ARI 210/240
	≥ 65,000 Btu/h and < 135,000 Btu/h	Split System and Single Package	11.5 EER[c]	
	≥135,000 Btu/h and ≤240,000 Btu/h	Split System and Single Package	11.0 EER[c]	ARI 340/360
	> 240,000 Btu/h	Split System and Single Package	11.0 EER[c] 10.3 IPLV[c]	

[a] Chapter 9 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.
[b] IPLVs are only applicable to equipment with capacity modulation.
[c] Deduct 0.2 from the required EERs and IPLVs for units with a heating section other than electric resistance heat.
[d] Single-phase air-cooled air-conditioners < 65,000 Btu/h are regulated by NAECA. SEER values are those set by NAECA.

TABLE 803.2.2 (2)
UNITARY AND APPLIED HEAT PUMPS, ELECTRICALLY OPERATED, MINIMUM EFFICIENCY REQUIREMENTS

Equipment Type	Size Category	Sub-Category or Rating Condition	Minimum Efficiency[b]	Test Procedure[a]
Air Cooled, (Cooling Mode)	< 65,000 Btu/h[d]	Split System	10.0 SEER	ARI 210/240
		Single Package	9.7 SEER	
	≥65,000 Btu/h and < 135,000 Btu/h	Split System and Single Package	10.1 EER[c]	
	≥135,000 Btu/h and <240,000 Btu/h	Split System and Single Package	9.3 EER[c]	ARI 340/360
	≥240,000 Btu/h	Split System and Single Package	9.0 EER[c] 9.2 IPLV[c]	
Water-Source (Cooling Mode)	< 17,000 Btu/h	85°F Entering Water		ARI 320
		86°F Entering Water	11.2 EER	ISO-13256-1
	≥ 17,000 Btu/h and <65,000 Btu/h	85°F Entering Water		ARI 320
		86°F Entering Water	12.0 EER	ISO-13256-1
	≥65,000 Btu/h and < 135,000 Btu/h	85°F Entering Water		ARI 320
		86°F Entering Water	12.0 EER	ISO-13256-1
Groundwater-Source (Cooling Mode)	< 135,000 Btu/h	70°F Entering Water		ARI 325
		59°F Entering Water	16.2 EER	ISO-13256-1
Ground Source (Cooling Mode)	< 135,000 Btu/h	77°F Entering Brine		ARI 330
		77°F Entering Water	13.4 EER	ISO-13256-1
Air Cooled (Heating Mode)	< 65,000 Btu/h[d] (Cooling Capacity)	Split System	6.8 HSPF	ARI 210/240
		Single Package	6.6 HSPF	
	≥65,000 Btu/h and < 135,000 Btu/h (Cooling Capacity)	47°F db/43°F wb Outdoor Air	3.2 COP	
	≥135,000 Btu/h (Cooling Capacity)	47°F db/43°F wb Outdoor Air	3.1 COP	ARI 340/360
Water-Source (Heating Mode)	< 135,000 Btu/h (Cooling Capacity)	70°F Entering Water		ARI 320
		68°F Entering Water	4.2 COP	ISO-13256-1
Groundwater-Source (Heating Mode)	< 135,000 Btu/h (Cooling Capacity)	70°F Entering Water		ARI 325
		50°F Entering Water	3.6 COP	ISO-13256-1
Ground Source (Heating Mode)	< 135,000 Btu/h (Cooling Capacity)	32°F Entering Brine		ARI 330
		32°F Entering Water	3.1 COP	ISO-13256-1

[a] Chapter 9 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.
[b] IPLVs and Part load rating conditions are only applicable to equipment with capacity modulation.
[c] Deduct 0.2 from the required EERs and IPLVs for units with a heating section other than electric resistance heat.
[d] Single-phase air-cooled heat pumps < 65,000 Btu/h are regulated by NAECA. SEER and HSPF values are those set by NAECA.

TABLE 803.2.2.(3)
PACKAGED TERMINAL AIR CONDITIONERS, PACKAGED TERMINAL HEAT PUMPS

Equipment Type	Size Category (Input)	Sub-Category or Rating Condition	Minimum Efficiency	Test Procedure[a]
PTAC (Cooling Mode) New Construction	All Capacities	95°F db Outdoor Air	12.5 - (0.213 x Cap/1000)[b] EER	ARI 310/380
PTAC (Cooling Mode) Replacements[c]	All Capacities	95°F db Outdoor Air	10.9 - (0.213 x Cap/1000)[b] EER	
PTHP (Cooling Mode) New Construction	All Capacities	95°F db Outdoor Air	12.3 - (0.213 x Cap/1000)[b] EER	
PTHP (Cooling Mode) Replacements[c]	All Capacities	95°F db Outdoor Air	10.8 - (0.213 x Cap/1000)[b] EER	
PTHP (Heating Mode) New Construction	All Capacities		3.2 - (0.026 x Cap/1000)[b] COP	
PTHP (Heating Mode) Replacements[c]	All Capacities		2.9 - (0.026 x Cap/1000)[b] COP	

[a] Chapter 9 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.
[b] Cap means the rated cooling capacity of the product in Btu/h. If the unit's capacity is less than 7000 Btu/h, use 7000 Btu/h in the calculation. If the unit's capacity is greater than 15,000 Btu/h, use 15,000 Btu/h in the calculation.
[c] Replacement units must be factory labeled as follows: "MANUFACTURED FOR REPLACEMENT APPLICATIONS ONLY; NOT TO BE INSTALLED IN NEW CONSTRUCTION PROJECTS." Replacement efficiencies apply only to units with existing sleeves less than 16-in. high and less than 42-in. wide.

TABLE 803.2.2 (4)
WARM AIR FURNACES, WARM AIR DUCT FURNACES AND UNIT HEATERS, MINIMUM EFFICIENCY REQUIREMENTS

Equipment Type	Size Category (Input)	Sub-Category or Rating Condition	Minimum Efficiency[d]	Test Procedure[a]
Warm Air Furnace, Gas-Fired	< 225,000 Btu/h (66 kW)		78% AFUE or 80% E_t[c]	DOE 10 CFR Part 430 or ANSI Z21.47
	≥225,000 Btu/h (66 kW)	Maximum Capacity[c]	80% E_c[f]	ANSI Z21.47
Warm Air Furnace, Oil-Fired	< 225,000 Btu/h (66 kW)		78% AFUE or 80% E_t[c]	DOE 10 CFR Part 430 or UL 727
	≥225,000 Btu/h (66 kW)	Maximum Capacity[b]	81% E_t[g]	UL 727
Warm Air Duct Furnaces, Gas-Fired	All Capacities	Maximum Capacity[b] Minimum Capacity[b]	80% E_c[e] _____	ANSI Z83.9
Warm Air Unit Heaters, Gas-Fired	All Capacities	Maximum Capacity[b] Minimum Capacity[b]	80% E_c[e] _____	ANSI Z83.8
Warm Air Unit Heaters, Oil-Fired	All Capacities	Maximum Capacity[b] Minimum Capacity[b]	80% E_c[e] _____	UL 731

[a] Chapter 9 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.
[b] Minimum and maximum ratings as provided for and allowed by the unit's controls.
[c] Combination units not covered by NAECA (3-phase power or cooling capacity greater than or equal to 65,000 Btu/h [19 kW]) may comply with either rating.
[d] E_t = Thermal efficiency. See test procedure for detailed discussion.
[e] E_c = Combustion efficiency (100% less flue losses). See test procedure for detailed discussion.
[f] E_c = Combustion efficiency. Units must also include an IID, have jacket losses not exceeding 0.75% of the input rating, and have either power venting or a flue damper. A vent damper is an acceptable alternative to a flue damper for those furnaces where combustion air is drawn from the conditioned space.
[g] E_t = Thermal efficiency. Units must also include an IID, have jacket losses not exceeding 0.75% of the input rating, and have either power venting or a flue damper. A vent damper is an acceptable alternative to a flue damper for those furnaces where combustion air is drawn from the conditioned space.

TABLE 803.2.2.(5)
BOILERS, GAS- AND OIL-FIRED, MINIMUM EFFICIENCY REQUIREMENTS

Equipment Type[f]	Size Category (Input)	Sub-Category or Rating Condition	Minimum Efficiency[c,e]	Test Procedure
Boilers, Gas-Fired	< 300,000 Btu/h	Hot Water	80% AFUE	DOE 10 CFR Part 430
		Steam	75% AFUE	
	≥300,000 Btu/h and ≤ 2,500,000 Btu/h	Maximum Capacity[b]	75% E_t	H.I. Htg Boiler Std
	> 2,500,000 Btu/h[f]	Hot Water	80% E_c	
	> 2,500,000 Btu/h[f]	Steam	80% E_c	
Boilers, Oil-Fired	< 300,000 Btu/h		80% AFUE	DOE 10 CFR Part 430
	≥300,000 Btu/h and ≤ 2,500,000 Btu/h	Maximum Capacity[b]	78% E_t	H.I. Htg Boiler Std
	> 2,500,000 Btu/h[f]	Hot Water	83% E_c	
	> 2,500,000 Btu/h[f]	Steam	83% E_c	
Oil-Fired (Residual)	≥300,000 Btu/h and ≤2,500,000 Btu/h	Maximum Capacity[b]	78% E_t	H.I. Htg Boiler Std
	> 2,500,000 Btu/h[f]	Hot Water	83% E_c	
	> 2,500,000 Btu/h[f]	Steam	83% E_c	

[a] Chapter 9 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.
[b] Minimum and maximum ratings as provided for and allowed by the unit's controls.
[c] E_c = Combustion efficiency (100% less flue losses). See reference document for detailed information.
[d] E_t = Thermal efficiency. See reference document for detailed information.
[e] Alternate test procedures used at the manufacturer's option are ASME PTC-4.1 for units over 5,000,000 Btu/h input, or ANSI Z21.13 for units greater than or equal to 300,000 Btu/h and less than or equal to 2,500,000 Btu/h input.
[f] These requirements apply to boilers with rated input of 8,000,000 Btu/h or less that are not packaged boilers, and to all packaged boilers. Minimum efficiency requirements for boilers cover all capacities of packaged boilers.

TABLE 803.3.2 (1)
CONDENSING UNITS, ELECTRICALLY OPERATED, MINIMUM EFFICIENCY REQUIREMENTS

Equipment Type	Size Category	Sub-Category or Rating Condition	Minimum Efficiency[b]	Test Procedure[a]
Condensing Units, Air Cooled	≥135,000 Btu/h		10.1 EER 11.2 IPLV	ARI 365
Condensing Units, Water or Evaporatively Cooled	≥135,000 Btu/h		13.1 EER 13.1 IPLV	

[a] Chapter 9 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.
[b] IPLVs are only applicable to equipment with capacity modulation.

TABLE 803.3.2.(2)
WATER CHILLING PACKAGES, MINIMUM EFFICIENCY REQUIREMENTS

Equipment Type	Size Category	Sub-Category or Rating Condition	Minimum Efficiency[b]	Test Procedure[a]
Air Cooled, With Condenser, Electrically Operated	< 150 Tons		2.80 COP 2.80 IPLV	ARI 550 or ARI 590 as appropriate
	≥150 Tons			
Air Cooled, Without Condenser, Electrically Operated	All Capacities		3.10 COP 3.10 IPLV	
Water Cooled, Electrically Operated, Positive Displacement (Reciprocating)	All Capacities		4.20 COP 4.65 IPLV	ARI 590
Water Cooled, Electrically Operated, Positive Displacement (Rotary Screw and Scroll)	< 150 Tons		4.45 COP 4.50 IPLV	ARI 550 or ARI 590 as appropriate
	≥150 Tons and < 300 Tons		4.90 COP 4.95 IPLV	
	≥300 Tons		5.50 COP 5.60 IPLV	
Water Cooled, Electrically Operated, Centrifugal[c]	< 150 Tons		5.00 COP 5.00 IPLV	ARI 550
	≥150 Tons and < 300 Tons		5.55 COP 5.55 IPLV	
	≥300 Tons		6.10 COP 6.10 IPLV	
Air Cooled Absorption Single Effect	All Capacities		0.60 COP	ARI 560
Water Cooled Absorption Single Effect	All Capacities		0.70 COP	
Absorption Double Effect, Indirect-Fired	All Capacities		1.00 COP 1.05 IPLV	
Absorption Double Effect, Direct-Fired	All Capacities		1.00 COP 1.00 IPLV	

[a] Chapter 9 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.
[b] The chiller equipment requirements do not apply for chillers used in low temperature applications where the design leaving fluid temperature is less than or equal to 40°F.
[c] Equipment not designed for operation at ARI Standard test conditions of 44 °F leaving chilled water temperature and 85 °F entering condenser water temperature shall have a minimum full load COP and IPLV rating as shown in Tables 703.3.2(3) through 703.3.2(5). The table values are only applicable over the following full load design ranges:

Leaving Chilled Water Temperature: 40 to 48 °F
Entering Condenser Water Temperature: 75 to 85 °F
Condensing Water Temperature Rise: 5 to 15 °F

Chillers designed to operate outside of these ranges are not covered by this standard.

TABLE 803.3.2 (3)
COPS AND IPLVS FOR NON-STANDARD CENTRIFUGAL CHILLERS < 150 TONS

Centrifugal Chillers < 150 Tons COP_{std} = 5.4								
			Condenser Flow Rate					
			2 gpm/ton	2.5 gpm/ton	3 gpm/ton	4 gpm/ton	5 gpm/ton	6 gpm/ton
Leaving Chilled Water Temperature (°F)	Entering Condenser Water Temperature (°F)	LIFT[a] (°F)	Required COP and IPLV					
46	75	29	6.00	6.27	6.48	6.80	7.03	7.20
45	75	30	5.92	6.17	6.37	6.66	6.87	7.02
44	75	31	5.84	6.08	6.26	6.53	6.71	6.86
43	75	32	5.75	5.99	6.16	6.40	6.58	6.71
42	75	33	5.67	5.90	6.06	6.29	6.45	6.57
41	75	34	5.59	5.82	5.98	6.19	6.34	6.44
46	80	34	5.59	5.82	5.98	6.19	6.34	6.44
40	75	35	5.50	5.74	5.89	6.10	6.23	6.33
45	80	35	5.50	5.74	5.89	6.10	6.23	6.33
44	80	36	5.41	5.66	5.81	6.01	6.13	6.22
43	80	37	5.31	5.57	5.73	5.92	6.04	6.13
42	80	38	5.21	5.48	5.64	5.84	5.95	6.04
41	80	39	5.09	5.39	5.56	5.76	5.87	5.95
46	85	39	5.09	5.39	5.56	5.76	5.87	5.95
40	80	40	4.96	5.29	5.47	5.67	5.79	5.86
45	85	40	4.96	5.29	5.47	5.67	5.79	5.86
44	85	41	4.83	5.18	5.40	5.59	5.71	5.78
43	85	42	4.68	5.07	5.28	5.50	5.62	5.70
42	85	43	4.51	4.94	5.17	5.41	5.54	5.62
41	85	44	4.33	4.80	5.05	5.31	5.45	5.53
40	85	45	4.13	4.65	4.92	5.21	5.35	5.44
Condenser DT[b]			14.04	11.23	9.36	7.02	5.62	4.68

[a] LIFT = Entering Condenser Water Temperature – Leaving Chilled Water Temperature
[b] Condenser DT = Leaving Condenser Water Temperature (F) – Entering Condenser Water Temperature (F)
$K_{adj} = 6.1507 - 0.30244(X) + 0.0062692(X)^2 - 0.000045595(X)^3$
where X = Condenser DT + LIFT
$COP_{adj} = K_{adj} * COP_{std}$

TABLE 803.3.2 (4)
COPS AND IPLVS FOR NON-STANDARD CENTRIFUGAL CHILLERS
> 150 TONS, £ 300 TONS

Centrifugal Chillers > 150 Tons, ≤ 300 Tons COP_{std} = 5.55								
			Condenser Flow Rate					
			2 gpm/ton	2.5 gpm/ton	3 gpm/ton	4 gpm/ton	5 gpm/ton	6 gpm/ton
Leaving Chilled Water Temperature (°F)	Entering Condenser Water Temperature (°F)	LIFT[a] (°F)	Required COP and IPLV					
46	75	29	6.17	6.44	6.66	6.99	7.23	7.40
45	75	30	6.08	6.34	6.54	6.84	7.06	7.22
44	75	31	6.00	6.24	6.43	6.71	6.90	7.05
43	75	32	5.91	6.15	6.33	6.58	6.76	6.89
42	75	33	5.83	6.07	6.23	6.47	6.63	6.75
41	75	34	5.74	5.98	6.14	6.36	6.51	6.62
46	80	34	5.74	5.98	6.14	6.36	6.51	6.62
40	75	35	5.65	5.90	6.05	6.26	6.40	6.51
45	80	35	5.65	5.90	6.05	6.26	6.40	6.51
44	80	36	5.56	5.81	5.97	6.17	6.30	6.40
43	80	37	5.46	5.73	5.89	6.08	6.21	6.30
42	80	38	5.35	5.64	5.80	6.00	6.12	6.20
41	80	39	5.23	5.54	5.71	5.91	6.03	6.11
46	85	39	5.23	5.54	5.71	5.91	6.03	6.11
40	80	40	5.10	5.44	5.62	5.83	5.95	6.03
45	85	40	5.10	5.44	5.62	5.83	5.95	6.03
44	85	41	4.96	5.33	5.55	5.74	5.86	5.94
43	85	42	4.81	5.21	5.42	5.66	5.78	5.86
42	85	43	4.63	5.08	5.31	5.56	5.69	5.77
41	85	44	4.45	4.93	5.19	5.46	5.60	5.69
40	85	45	4.24	4.77	5.06	5.35	5.50	5.59
Condenser DT[b]			14.04	11.23	9.36	7.02	5.62	4.68

[a] LIFT = Entering Condenser Water Temperature – Leaving Chilled Water Temperature
[b] Condenser DT = Leaving Condenser Water Temperature (F) - Entering Condenser Water Temperature (F)
$K_{adj} = 6.1507 - 0.30244(X) + 0.0062692(X)^2 - 0.000045595(X)^3$
where X = Condenser DT + LIFT
$COP_{adj} = K_{adj} * COP_{std}$

TABLE 803.3.2(5)
COPS AND IPLVS FOR NON-STANDARD CENTRIFUGAL CHILLERS > 300 TONS

Centrifugal Chillers > 300 Tons COP_{std} = 6.1								
			Condenser Flow Rate					
			2 gpm/ton	2.5 gpm/ton	3 gpm/ton	4 gpm/ton	5 gpm/ton	6 gpm/ton
Leaving Chilled Water Temperature (°F)	Entering Condenser Water Temperature (°F)	LIFT[a] (°F)	Required COP and IPLV					
46	75	29	6.80	7.11	7.35	7.71	7.97	8.16
45	75	30	6.71	6.99	7.21	7.55	7.78	7.96
44	75	31	6.61	6.89	7.09	7.40	7.61	7.77
43	75	32	6.52	6.79	6.98	7.26	7.45	7.60
42	75	33	6.43	6.69	6.87	7.13	7.31	7.44
41	75	34	6.33	6.60	6.77	7.02	7.18	7.30
46	80	34	6.33	6.60	6.77	7.02	7.18	7.30
40	75	35	6.23	6.50	6.68	6.91	7.06	7.17
45	80	35	6.23	6.50	6.68	6.91	7.06	7.17
44	80	36	6.13	6.41	6.58	6.81	6.95	7.05
43	80	37	6.02	6.31	6.49	6.71	6.85	6.94
42	80	38	5.90	6.21	6.40	6.61	6.75	6.84
41	80	39	5.77	6.11	6.30	6.52	6.65	6.74
46	85	39	5.77	6.11	6.30	6.52	6.65	6.74
40	80	40	5.63	6.00	6.20	6.43	6.56	6.65
45	85	40	5.63	6.00	6.20	6.43	6.56	6.65
44	85	41	5.47	5.87	6.10	6.33	6.47	6.55
43	85	42	5.30	5.74	5.98	6.24	6.37	6.46
42	85	43	5.11	5.60	5.86	6.13	6.28	6.37
41	85	44	4.90	5.44	5.72	6.02	6.17	6.27
40	85	45	4.68	5.26	5.58	5.90	6.07	6.17
Condenser DT[b]			14.04	11.23	9.36	7.02	5.62	4.68

[a] LIFT = Entering Condenser Water Temperature – Leaving Chilled Water Temperature

[b] Condenser DT = Leaving Condenser Water Temperature (F) - Entering Condenser Water Temperature (F)

K_{adj} = 6.1507 - 0.30244(X) + 0.0062692$(X)^2$ - 0.000045595$(X)^3$

where X = Condenser DT + LIFT

$COP_{adj} = K_{adj} * COP_{std}$

TABLE 803.3.2(6)
PERFORMANCE REQUIREMENTS FOR HEAT REJECTION EQUIPMENT

Equipment Type	Total System Heat Rejection Capacity at Rated Conditions	Sub-Category or Rating Condition	Performance Required[a,b]	Test Procedure[c]
Propeller or Axial Fan Cooling Towers	All	95°F (35°C) Entering Water 85°F (29°C) Leaving Water 75°F (24°C) wb Outdoor Air	≥38.2 gpm/hp (3.23 L/s·kW)	CTI ATC-105 and CTI STD-201
Centrifugal Fan Cooling Towers	All	95°F (35°C) Entering Water 85°F (29°C) Leaving Water 75°F (24°C) wb Outdoor Air	20.0 gpm/hp (1.7 L/s·kW)	CTI ATC-105 and CTI STD-201
Air Cooled Condensers	All	125°F (52°C) Condensing Temperature R22 Test Fluid 190°F (88°C) Entering Gas Temperature 15°F (8°C) Subcooling 95°F (35°C) Entering Drybulb	≥176,000 Btu/h·hp (69 COP)	ARI 460

[a] For purposes of this table, cooling tower performance is defined as the maximum flow rating of the tower divided by the fan nameplate rated motor power.
[b] For purposes of this table air-cooled condenser performance is defined as the heat rejected from the refrigerant divided by the fan nameplate rated motor power.
[c] Chapter 9 contains a complete specification of the referenced test procedure, including the referenced year version of the test procedure.