BUILDING HVAC (2) REQUIREMENTS

COMPLEX SYSTEMS

CHAPTER 5
COMMERCIAL ENERGY EFFICIENCY

2011 New York City Energy Conservation Code
Effective from December 28, 2010
The New York City Department of Buildings wishes to acknowledge the generous grant from the United States Department of Energy under the American Recovery and Reinvestment Act, enacted by President Obama and Congress in 2009. This grant funded the creation of these training modules; without this support, these materials would not have been possible.

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This training module was developed by:

Viridian Energy & Environmental, LLC
Welcome to the New York City Department of Buildings Energy Code Training Modules!

This HVAC-2: Complex Systems Module addresses:

- Technical issues and strategies related to Complex Systems in 2011 NYCECC
- NYC DOB Energy Code Submission Requirements & Progress Inspection requirements

This module addresses HVAC criteria related to all commercial building types, including Group R Buildings: R-1 uses (any height); R-2 and R-3, when over 3 stories.

HVAC criteria related to low-rise residential buildings are covered under the NYC DOB Residential Training Module. This module is a continuation of HVAC-1: Mandatory Requirements & Simple HVAC Systems.
The HVAC-2: Complex Systems Module has been divided into a number of smaller sub-topics. These can be accessed either in-sequence or out-of-sequence through links in the main “Menu” slide.

Each sub-topic begins with a brief overview of the issues to be reviewed, and many end with a set of summary questions or exercises.

Many of the sub-topics are organized in a Q & A format. Code-related questions are posed at the top of a slide, with answers provided below, or in the following sequence of slides.
The **NYC Buildings** logo takes you to the 2011 NYCECC Training Modules home page.

The **Menu** icon takes you to the main menu page within each module.

The **Attention** icon brings up Callouts with key points and additional information.

The **Links** icon takes you to related DOB web pages or other resources.

The **Documentation** icon addresses DOB documentation issues and requirements.

The **Inspection** icon addresses DOB Progress Inspection issues and requirements.

The **Code Reference** icon refers to relevant Code sections.
Look for the following icons:

- **The NYC Buildings logo** takes you to the 2011 NYCECC Training Modules home page.
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- **The Inspection icon** addresses DOB Progress Inspection issues and requirements.
- **The Code Reference icon** refers to relevant Code sections.

The slides are enhanced with special icons that will help to focus on key points, or serve as links to external resources. The Attention icon brings up Callouts (like this one) with key points and additional information.
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The main menu slide is interactive; clicking on each line item will take you to the respective sub-module. Use this feature to navigate throughout the presentation. The menu icon at the bottom right corner of each slide will always bring you back to the main menu slide.
1. Multiple Zone Air-side Systems

In this section you will learn about:

- Code requirements for Complex air-side HVAC systems;
- Overview of Variable Air Volume (VAV) systems including general concepts, review of schematics for different configurations and key components; and
- Understand differences and requirements for Single Duct VAV, Dual Duct VAV, Single Fan Dual Duct & Mixing VAV systems.
1. Multi-Zone

What are key Code requirements for HVAC systems serving multiple zones?

System Type Requirements:

- Air Side HVAC system serving multiple zones (or multi-zone systems) are treated as Complex HVAC
  - Systems that do not fit Simple HVAC system definition will be treated as Complex systems.

- Multiple zone air-side systems must be Variable Air Volume (VAV) type
  - Constant Air Volume (CAV or CV) system is limited and restricted

- Allowed exceptions to VAV requirement for zones:
  - With special pressurization requirements (e.g., hospitals, labs, etc)
  - With peak supply air less than 300 cfm or less
  - Where volume of air is no greater than minimum ventilation
  - Where special humidity levels are required (e.g., data center, library, museum)
  - Systems where controls prevent reheating, recooling, mixing air that has been heated or cooled, or
  - Systems where 75% of reheat energy is from site recovered sources (e.g., solar, condenser water recovery)
1. Multi Zone

What are key Code requirements for HVAC systems serving multiple zones?

**VAV Air Management Requirements:**
- Capability to control and **reduce primary air** supply to each zone
- Primary air volume shall be reduced to the greater of the following before reheating, recooling, or mixing:
  - Condition 1: 30% of max supply air to each zone 
  - Condition 2A or 2B: 300 CFM or less if max flow rate is less than 10% of total fan system supply air flow rate
  - Condition 3: Minimum Ventilation rate per NYC Mech. Code

**VFD Requirement for Fan Motors:**
- VFDs are required for individual fans greater than 10 HP in size
- VFD must meet one of the following:
  - The fan motor shall be driven by a mechanical or electrical Variable Speed Drive or Variable Frequency Drive
  - The fan motor shall have controls or devices that will result in fan motor demand of no more than 30% of their design wattage at 50% of the design airflow
Multi-Zone Systems

1. Multi Zone

How is minimum Primary Air Volume calculated for a VAV zone?

Case In Point:

Q: 5000 ft² classroom served by VAV fan system. Total design supply air is specified at 8000 cfm. What is the minimum primary air for this zone?

Calculations

- Condition 1: 30% of design supply-air to zone:
  » 8000 CFM x 30% = 2400 CFM
- Condition 2a or 2b: 300 CFM or less if 10% of fan system’s design supply-air:
  » 8000 CFM x 10% = 800 CFM
- Condition 3: Ventilation rate: NYS Mechanical Code
  » 5000 ft² x 50 persons/1000 ft² x 15 CFM/person = 3750 CFM
  » less than 3750 CFM per active DCV control, no lower than 2400 CFM

A: Not required to be less than 3,750 cfm; however, with DCV control it could go as low as 2,400 cfm or lower depending on performance of the diffusers and VAV boxes.
Heating/Cooling/Air Treatment Components:

- **Preheat Coil:**
  - Preheats outside air to prevent frosting of cooling coil and partial heating capacity
- **Cooling Coil:**
  - Provides cooling capacity (sensible + latent)
  - Can be Direct Expansion (DX) or connected to a chilled water system
- **Heating Coil:**
  - Provides partial heating capacity (reheat load)
- **Humidifier:**
  - Increases moisture content in the supply air
- **Economizer:**
  - Enables introduction of additional outside air to meet some or all of the cooling load when outside air conditions are suitable
- **Exhaust Air Energy Recovery:**
  - Preheats or pre-cools outside air by recovering energy from exhaust air

Code Impacts: Terminal VAV box volume control, economizer, energy recovery, supply temperature reset controls, damper controls, fan power limits.
1. Multi-Zone

**Variable Air Volume (VAV) Description**

**What components are commonly found in a typical Single Duct VAV System? (Cont.)**

**Fan Components:**
- Supply Fan:
  - Provides supply air to zones
- Return Fan:
  - Returns space air to the air handler
- Exhaust Fan:
  - Removes air directly from space to outside
  - Relief fan may be provided for Economizer operation

**Terminal Devices:**
- Consist of supply air dampers to control volume
- May consist of reheat coils to control supply air temperature in heating mode
- May have a local recirculation fan (fan-powered box)

**Thermostats:**
- Controls operation in terminal units of supply air damper, reheat coils and baseboards

**Single Duct VAV System**

**System Schematic**

**Code Impacts:** Fan power limits, terminal device air volume control, thermostat set points & set backs
Single-Duct VAV systems, Terminal Devices:
- Systems have one duct usually providing cool air to terminal devices with dampers and sometimes reheat coils
- Terminal devices must reduce the supply of primary supply air before reheating or re-cooling takes place
  - Reduces unnecessary heating & cooling

Dual-Duct & Mixing VAV Systems, Terminal Devices:
- Systems have one warm air duct and one cool air duct.
- Terminal devices must reduce the flow from one duct to a minimum before mixing air from the other duct
  - Reduces unnecessary heating & cooling

Progress inspection at terminal boxes for temperature and air volume control. Minimum of 15% of terminal equipment must be tested.
Dual-Duct VAV Systems

1. Multi-Zone

What are the key Code requirements for a Dual-Duct System?

**Requirements at Air Handler:**
- Fan power limits, VFD, economizer, temperature reset controls, thermostat controls, DCV, damper controls
- **Economizer prohibited if total capacity exceeds 90,000 Btu/h**
- Typical components at Air-Handler
  - Central preheat coil
  - Separate supply ducts for heating and cooling (heating/cooling coils in ducts)
  - Central supply & return fans

**Code requirements for Mixing Boxes:**
- Reduce cold & hot air before mixing
- Supply temperature control for cooling & heating
  - Intent: Reduce energy use due to unnecessary heating and cooling
2. Air-Side Economizers

In this section you will learn about:

- Code requirements for use of Air-Side Economizers;
- Types of Economizers and schematics; and
- Allowable exceptions for Economizer requirements.
Air-side Economizer Requirements

2. Economizers

When does economizer requirement become mandatory?

Economizer requirements similar to Simple HVAC Systems:

- All counties in NYC (climate zone 4-A) must follow this requirement

- **Exceptions:**
  - Systems with less than 54,000 Btu/h (4.5 tons) cooling capacity
  - Systems utilizing water-side Economizers
  - Systems which serve open-case refrigeration or that require filtration equipment to meet Code ventilation requirements

- **Prohibited:**
  - Economizer prohibited in single fan dual duct mixing VAV system with greater than 90,000 Btu/h capacity

ASHRAE 90.1-2007 doesn’t require Economizers for climate zone 4-A

Air Side Economizer Schematic

Progress inspection requires verification of minimum of 20% of Economizers operation during appropriate seasons. This includes controls, dampers, fans and mechanical cooling.
Psychrometric Properties of Air

2. Economizers

What properties of air are important for influencing economizer operation?

**Temperature:**
- Increasing temperature means higher (sensible) energy in the air, and also raises the amount of water the air is capable of containing.

**Humidity:**
- Humidity is a measure of the moisture content of air.
- Increasing humidity means higher (latent) energy in the air, which puts a higher load on a cooling system for dehumidification purposes.
- Can be determined by the wet-bulb temperature of the ambient air.

**Enthalpy:**
- Measures total energy (sensible + latent) in the air (units are Btu/Lb).
- Warmer, more moist air will always contain more energy than colder, drier air.
- Cold, moist air can contain more energy than hot, dry air!
Types of Air-side Economizers

2. Economizers

What is economizing and what are the different types of controls?

Air-side Economizer:
- Directly introducing filtered, but unconditioned outdoor air, with a lower enthalpy or temperature than the conditioned space, to fully or partially satisfy the cooling load

Economizer Control Methods:
- Fixed Temperature (High-Limit Shut-off)
  - Measures outside air (OA) temperature only
  - Uses outside air for cooling up to the high-limit temp.
- Fixed Enthalpy (High-Limit Shut-off)
  - Measures OA temperature & humidity
  - Uses OA for cooling up to the high-limit enthalpy
- Dual (Differential) Temperature
  - Measures OA and return air (RA) temperature
  - Uses OA for cooling when OA temp. < RA temp.
- Dual (Differential) Enthalpy
  - Measures OA & RA temperature & humidity
  - Uses OA for cooling when the OA enthalpy < RA enthalpy

Economizers must be indicated on HVAC equipment schedules. Control type and sequence of operation must be provided in drawings.
Types of Air-side Economizers

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  - Measures OA & RA temperature & humidity
  - Uses OA for cooling when the OA enthalpy < RA enthalpy

Economizers must be indicated on HVAC equipment schedules. Control type and sequence of operation must be provided in drawings.

Actually prohibited by ASHRAE 90.1-07 for other climate zones, but economizer is not required in NYC (4A) under ASHRAE 90.1-07.

In any case, this economizer control strategy is not recommended for the NYC climate.
In this section you will learn about:

- Thermostatic control requirements;
- Supply air reset controls requirements; and
- Static pressure and fan control requirements.
Thermostat Location / Placement Requirement:
- Thermostats must be located within each zone AND must control space temperature.

Control Dead-Band Requirement:
- Heating & cooling set-points must be sufficiently far apart so the unit does not over-respond when in one mode of operation and require a correction from the other.
  - Code minimum is 5°F

Night/Unoccupied Setback Requirement:
- Lower heating and higher cooling set-points required during nights/unoccupied periods
- Outside air intake must be reduced, or stopped, during the unoccupied period

Thermostat locations must be indicated on zone level plans. Control set points and setback must be indicated in sequence of operations.

Visual inspection required in minimum of 20% sample of units for effective operation for set points, set backs and off-hour controls as part of DOB Progress Inspections.
Supply Air Temperature Controls

3. Controls

What are the rules governing the supply air temperature controls?

Supply Air Temperature Reset:

- Automatic controls required for multiple zone systems to reset supply air temperature.
  - In response to zone loads (and / or)
  - In response to outdoor air temperature (& humidity)
    » Intent: Reduces the heating and cooling energy during low-load conditions

- Minimum required reset: 25% of the difference between design supply air & space temperature

- Exceptions:
  - Systems that prevent (entirely) reheating, recooling, or mixing of heated and cooled supply air
  - Systems in which 75% of the energy for reheating is from site-recovered or site solar energy sources
  - Zones with peak supply air quantities of 300 CFM or less

Supply air temperature reset control must be indicated on drawings

Sample of 20% of these controls must be verified during Progress Inspections
Supply Air Temperature Controls

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Supply air temperature reset control must be indicated on drawings

Sample of 20% of these controls must be verified during Progress Inspections

For example, a typical design temperatures are 55°F supply air and a 75°F space temperatures.

Thus, 25% of the 20°F design temperature difference is 5°F, and the system would have to increase the supply air temperature based on load to 60°F during low load conditions.
3. Controls

What are the Details of Static Pressure and Fan Controls?

**Static Pressure (SP) Reset:**
- SP based reset control required where there is DDC control at VAV boxes
  - Intent: Reduces fan energy consumption when loads are satisfied in most zones.

**Fan Controls:**
- Electrical or mechanical variable speed drives are required for fan motors greater than 10 HP.
  - Or fan control device results in 30% design power at 50% design flow when SP set-point is 33% of total design static pressure.

DDC & SP Reset control must be indicated on drawings
Sample of 20% of SP Reset controls must be verified during Progress Inspections
In this section you will learn about:

- What a Chiller is – as well as different Chiller technologies such as Vapor-Compression Chillers and Absorption Chillers;

- Condenser types; and

- Rating conditions / controls.
Review of Basic Refrigeration Cycle:

- Chillers extract heat and cool a liquid (Water, Brine, Glycol)
  - Can use a Vapor Compression or Absorption Cycle
- Condensers reject heat
  - Can be air-cooled or water-cooled

Vapor Compression Chiller Types:

- Positive Displacement
  - Reciprocating
  - Rotary (Screw & Scroll)
- Centrifugal
How are Chillers Rated for Efficiency?

**EER (Energy Efficiency Ratio):**
- Denotes full-load efficiency
- Typically used for air-cooled Chillers

**KW/Ton:**
- Full- and part-load efficiency metric
- Typically used for water-cooled Centrifugal and Positive Displacement Chillers

**COP (Coefficient Of Performance):**
- Full- and part-load efficiency metric
- Absorption Chillers

**Meet One of Two Compliance Paths:**
- Compliance Path-A:
  - Optimized for full-load operation – ideal for base-loaded Chillers
- Compliance Path-B:
  - Optimized for part-load operation – ideal for trim-loaded Chillers

Chiller efficiency at full-load and IPLV must be indicated on drawings and must correspond to design chilled water (CLWT) temperatures and condenser water temperature (CEWT) & flow rates per AHRI 550/590 standard or must follow NPLV calculation method.

100% of the Chillers must be verified during Progress Inspections. Name plate and manufacturer’s test data must be furnished in Supporting Documentation.

Chiller Efficiency Requirements: Table 503.2.3(7) & NPLV: 503.2.3
4. Chillers

How are chillers rated for efficiency?

AHRI 550/590:
- Standard utilized for rating Chillers

EER (Energy Efficiency Ratio):
- Single efficiency rating point at full load:
  ▶ Chilled Water: 44°F @ 2.4 GPM / Flow Rate
  ▶ Condensing Water: 85°F (Water-Cooled) @ 3 GPM / Ton Flow Rate
  ▶ Air Cooled: 95°F Outdoor Air Temp

IPLV (Integrated Part-Load Value):
- Calculated from multiple efficiency rating points:
  ▶ Efficiency metric for measuring part-load conditions
  ▶ Weighted average calculation taken at the part-load scenarios

NPLV (Nonstandard Part-Load Value):
- For non AHRI 550/590 rating conditions

### IPLV Rating Conditions

<table>
<thead>
<tr>
<th>Load</th>
<th>% Time</th>
<th>Condenser Water Temp.</th>
</tr>
</thead>
<tbody>
<tr>
<td>100%</td>
<td>1%</td>
<td>85</td>
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<tr>
<td>75%</td>
<td>42%</td>
<td>75</td>
</tr>
<tr>
<td>50%</td>
<td>45%</td>
<td>65</td>
</tr>
<tr>
<td>25%</td>
<td>12%</td>
<td>65</td>
</tr>
</tbody>
</table>

Chiller efficiency at full load & IPLV must be indicated on drawings and must correspond to design chilled-water (CLWT) temperatures and condenser-water temperature (CEWT) & flow rates per AHRI 550/590 standard or per NPLV calculation method.

100% of the must be verified during Progress Inspections

ASHRAE has look-up tables for different non-standard scenarios.
## Chiller Efficiency Requirements

### 4. Chillers

**How are Chillers Rated for Efficiency?**

<table>
<thead>
<tr>
<th>Water Chilling Packages, Minimum Requirements</th>
<th>Path A</th>
<th>Path B</th>
<th>Test Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Equipment Type</strong></td>
<td><strong>Size Category</strong></td>
<td><strong>Units</strong></td>
<td><strong>Full Load</strong></td>
</tr>
<tr>
<td>Air Cooled Chiller</td>
<td>&lt; 150 Tons</td>
<td>EER</td>
<td>&gt;= 9.562</td>
</tr>
<tr>
<td></td>
<td>&gt;= 150 Tons</td>
<td>EER</td>
<td>&gt;= 9.562</td>
</tr>
<tr>
<td>Air Cooled, without Condenser, electrically operated</td>
<td>All Capacities</td>
<td>EER</td>
<td>Air Cooled chillers without condensers must be rated with matching condensers and comply with the air cooled chiller efficiency requirements</td>
</tr>
<tr>
<td>Water Cooled, Electrically operated, Reciprocating</td>
<td>All Capacities</td>
<td>kW/Ton</td>
<td>Reciprocating Units must comply with water cooled positive displacement efficiency requirements</td>
</tr>
<tr>
<td></td>
<td>&lt; 75 Tons</td>
<td>kW/Ton</td>
<td>&lt;= 0.775</td>
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<td>&gt;= 75 Tons &amp; &lt;150 Tons</td>
<td>kW/Ton</td>
<td>&lt;= 0.680</td>
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<tr>
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<td>&gt;= 150 Tons &amp; &lt;300 Tons</td>
<td>kW/Ton</td>
<td>&lt;= 0.620</td>
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<tr>
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<td>&gt; 300 Tons</td>
<td>kW/Ton</td>
<td>&lt;= 0.604</td>
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<tr>
<td>Water Cooled, Electrically operated, Positive Displacement</td>
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<td>kW/Ton</td>
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<td>kW/Ton</td>
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<td>kW/Ton</td>
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<tr>
<td></td>
<td>&gt; 150 Tons</td>
<td>kW/Ton</td>
<td>&lt;= 0.570</td>
</tr>
</tbody>
</table>

*Establish applicable equipment type and size, and select between Path A or Path B for compliance. Ensure the efficiency values are derived for standard rating conditions. Other rating conditions are allowed if they follow NPLV method.*
Efficiency Metrics

4. Chillers

Which Chiller Efficiency Metrics Apply for Non-Standard Operating Conditions?

NPLV (Non-standard Part-Load Value):
- Single number part-load efficiency metric analogous to IPLV
- Different rating conditions (non-standard) than for IPLV
- Applicable for non-standard operating conditions within limits:
  - Minimum leaving chilled water 38°F
  - Maximum condensing entering water temperature: 102°F
  - Condensing water flow rate: 1 to 6 gpm/ton
- Calculation formula: Refer to Code

Non Standard Adjustment Factor

Full Load and IPLV values from Table 503.2.3(7)

Adjusted Values = Table values / \( K_{\text{adj}} \)

\( K_{\text{adj}} = 6.174722 - 0.303668(X) + 0.00629466 (X)^2 - 0.000045780 (X)^3 \)

\( X = DT_{\text{std}} + \text{LIFT} \)

\( DT_{\text{std}} = \{ 24 + [\text{Full load kW/ton from table } 503.2.3(7)] \times 6.83 \} / \text{Flow} \)

Flow = Condenser Water Flow (GPM) Cooling Full Load Capacity (tons)

Lift = CEWT – CLWT (°F)

CEWT = Full Load Condenser Entering Water Temperature (°F)

CLWT = Full Load Leaving Chilled Water Temperature (°F)

Code Exempt Chiller Applications:
- Chillers operating outside these ranges
- Applications utilizing fluids or solutions with secondary coolants with freeze point less than 27°F (e.g., brine, water/glycol)

Supporting Documents must include all values needed for \( K_{\text{adj}} \)
What are the Different Types of Compressors Used in Chillers?

Positive Displacement Chillers:

- **Operating principle:** Refrigerant gas becomes trapped within a chamber whose volume decreases as it is mechanically compressed.

- **Reciprocating:**
  - Constructed similar to a car engine
  - Motor turns crankshaft
  - Pistons compress refrigerant gas
  - Typical capacity 2 - 60 tons

- **Rotary Screw:**
  - Helical Screws mesh and rotate together
  - Refrigerant gas compressed as volume between screws decreases
  - Typical capacity 70 - 200 tons (up to 500 tons)

- **Rotary Scroll:**
  - Two spiral scrolls 1 stationary, 1 orbiting
  - Refrigerant gas compressed as volume between scrolls decreases
  - Typical capacity 20 - 200 tons (up to 500 tons)
4. Chillers

**What are the different types of compressors used in Chillers?**

**Centrifugal:**

- Similar to centrifugal pump in construction
  - Vaned impeller spins in volute casing
  - Refrigerant gas enters through the axis of the impeller
  - Gas exits the impeller radially at high velocity
  - Velocity is converted to pressure as the gas collides with the volute casing
- Typical capacity: 100 - 3,500 tons
  - Practical limit > 200 tons due to cost
  - Field-fabricated units up to 10,000 tons

**Centrifugal - Schematic**

Most prevalent electrically driven Chiller type over 200 tons.

Chiller Efficiency Requirements: Table 503.2.3(7) & NPLV: 503.2.3
Absorption Chillers

4. Chillers

How is an Absorption Chiller Different from a Vapor Compression Chiller?

Mechanical compressor is replaced by “thermal compressor”

Lithium Bromide is the typical absorber chemical used in the process

Thermal input options:
- Indirect (steam or hot water)
- Direct (gas-fired)

Requires larger heat rejection (Cooling Tower)

Two general types:
- 1-stage (single effect)
  - Less efficient (COP ≈ 0.6 - 0.7)
  - Can use lower temperature (grade) heat
  - Typical Capacity: 50 – 1700 tons (also 5 – 10T)
- 2-stage (double effect)
  - Higher efficiency (COP ≈ 1.0 - 1.2)
  - Requires high temperature (grade) heat
  - Typical Capacity: 100 - 1700 tons (also 20-100T)
Absorption Chillers

4. Chillers

How is an Absorption Chiller Different from a Vapor Compression Chiller?

Mechanical compressor is replaced by “thermal compressor”

Lithium Bromide is the typical absorber chemical used in the process

Thermal input options:

- Indirect (steam or hot water)
- Direct (gas-fired)

Requires larger heat rejection (Cooling Tower)

Two general types:

- 1-stage (single effect)
  - Less efficient (COP ≈ 0.6 - 0.7)
  - Can use lower temperature (grade) heat
  - Typical Capacity: 50 – 1700 tons (also 5 – 10T)
- 2-stage (double effect)
  - Higher efficiency (COP ≈ 1.0 - 1.2)
  - Requires high temperature (grade) heat
  - Typical Capacity: 100 - 1700 tons (also 20-100T)

Absorption System - Schematic

A larger cooling tower can be used for increased water side economizer function.

Low grade heat includes low pressure steam and medium temperature hot water. Although lower efficiency, these units can make use of site recovered heat.

High grade heat includes high pressure steam and high temperature hot water. Although higher efficiency, it is more difficult for these units to make use of site recovered heat from many sources.

Chiller Efficiency Requirements: Table 503.2.3(7) & NPLV: 503.2.3
For individual Chillers:

- Staging & sequencing multiple compressors
- Use of Variable Speed Drives & motors
- Hot Gas Bypass
  - Code only allows Hot Gas Bypass if equipment has multiple steps of unloading.

For Chiller plants:

- Staging of multiple Chillers
  - Consider efficiency curves for each Chiller to maximize plant efficiency for given load
- Base loaded Chillers
  - These chillers operate much of the time at or near full load to maximize full-load efficiency (recommended Path A method)
- Others
  - These chillers see varying loads
  - Maximize seasonal efficiency (recommended Path B method)
5. Heat Rejection Equipment

Learning Objectives

In this section you will learn about:

- Applications That Need Heat Rejection Devices;
- Types of Heat Rejection Devices;
  - Dry Cooler
  - Open Cooling Tower
  - Closed-Circuit Evaporative Cooler
- Control Requirements; and
  - Fan Speed
  - Applications in Heat Pump Loop
- Condenser Heat Recovery & Water-side Economizer.
Heat Rejection Devices

5. Heat Rejection

How do Air Conditioning System Chillers Reject Heat?

Cooling devices (Vapor compression & Absorption) use Condensers to reject heat

Water-cooled Condenser:
- Need condenser water loop and cooling tower (or ground)
- Chiller ratings don’t include condenser water system energy (i.e., pumps and tower fans)

Air-cooled Condenser:
- Packaged or separate air-cooled condenser
- Chiller ratings must include condenser fan energy
Cooling devices (Vapor compression & Absorption) use Condensers to reject heat

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Air-cooled Condenser:
- Packaged or separate air-cooled condenser
- Chiller ratings must include condenser fan energy

NYCECC requires air-cooled chillers without condensers to be rated with matching condensers and must then comply with the air-cooled chiller efficiency requirements. The code, however, does include separate efficiency requirements for air-cooled condensing units.

ASHRAE 90.1 provides efficiency requirement for air-cooled chillers without condensers, and allows them to be rated as such. ASHRAE also includes efficiency requirements for remote air–cooled condensers.
5. Heat Rejection

What type of condenser is associated with an Air-Cooled Chiller?

**Features:**
- Air-cooled
- Capacity and efficiency driven by ambient dry-bulb temperature
- DX systems (Condenser or Condensing Unit)

**Pros:**
- Simple
- Low maintenance
- Inexpensive
- No freeze issues

**Cons:**
- Low efficiency

An air-cooled condenser is a type of dry cooler.
Closed-Circuit Cooling Tower

5. Heat Rejection

What type of condensers are associated with Water-Cooled Chillers?

Features:
- Condenser water not in direct contact with atmosphere
- Capacity and efficiency driven by ambient wet-bulb temperature

Pros:
- More efficient than Air-cooled
- Can operate in winter as a Dry Cooler
  - Requires glycol in condenser water loop
- Condenser water isolated from ambient
  - Contamination reduced

Cons:
- Requires make up water
- Higher maintenance than Dry Cooler
- Separate tower pump needs to be operated

Closed-circuit cooling tower is also known as an evaporative (or evap) cooler.

Condenser Fan Speed Control: 503.4.4; Heat pump loop connection options: 503.4.3.3.2.1
What type of condensers are associated with Water-Cooled Chillers?

Features:
- Condenser water in direct contact with ambient air
- Capacity and efficiency driven by ambient wet-bulb temperature

Pros:
- More efficient than Dry Coolers
- Typically more efficient than Evap Coolers

Cons:
- Requires make-up water
- Condenser water must be filtered to control contamination
- Higher maintenance than Dry Cooler or Evaporative Cooler
Heat Rejection Performance

5. Heat Rejection

What applications of heat rejection devices are governed by Code?

Condensing Units efficiency:
- Air-cooled
- Water and evaporatively cooled

Heat rejection fan speed control

Hydronic (water loop) HP systems

Condenser Heat Recovery:
- Required for some facilities with water-cooling condensers

Water Economizer:
- Tower(s) create cooling water directly
- Exemption for air economizer if performance requirements are met

Fan speed control must be inspected & verified for proper operation as part of Progress Inspections

Tables 503.2.3 6 & 503.2.3 7; Water Economizer: 503.4.1 Exception; Condenser Heat Recovery: 503.4.6; Heat Rejection Fans: 503.4.4
Heat Rejection Performance

5. Heat Rejection

How does heat rejection equipment control capacity?

Performance and capacity are based on:
- Dry Coolers: dry-bulb temperature
- Evap or Open Towers: ambient wet-bulb temperature

Capacity is controlled by fan speed

Fan Control Options:
- Cycling/Staging (On-Off)
- Two-Speed Fans
- Variable-Speed Fans

- Code requirements for fans greater than 7.5 HP
  - Capacity to operate at 2/3 speed or less
  - Controls shall automatically adjust fan speed based on ...
    - Towers: temperature of leaving fluid, or
    - Condensing Units: condensing temperature & pressure
  - Exception for fans which are included in the rated efficiency of Condensing Units and Chillers
Hydronic Heat-Pump Systems:

- **Water-loop temperature control deadband required.**
- **Heat loss through tower shall be controlled as follows:**
  - Closed-circuit tower with direct connection to HP loop
    - An automatic valve shall bypass water flow around the tower, or
    - Low-leakage positive closure dampers shall prevent airflow through the tower
  - Open-circuit tower with direct connection to HP loop
    - An automatic valve shall bypass water flow around the tower
  - Open- or closed-circuit tower with a heat exchanger between HP loop and tower
    - Tower water-loop pump shall shut down

Tower water temperature control, bypass valve control, tower dampers, and tower pump controls need to be verified and operation tested.
Hydronic Heat-Pump Systems:

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  - Closed-circuit tower with direct connection to HP loop
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    - An automatic valve shall bypass water flow around the tower
  - Open- or closed-circuit tower with a heat exchanger between HP loop and tower
    - Tower water-loop pump shall shut down
Supplementing Service Water Heating:

- **Required when heating or reheating service hot water when:**
  - Facility operates 24 / 7
  - Cooling capacity of water-cooled systems exceeds 6,000,000 Btu/h 500 tons of heat rejection

  AND

  - **Design** service water heating load exceeds 1,000,000 Btu/h (e.g., Hospitals)

- **Required capacity is the smaller of:**
  - 60% of peak heat rejection load at design conditions

  OR

  - Preheating to 85°F for peak service hot water draw
Water Economizer:

- Use condenser water directly to meet cooling loads
- Integrated vs. non-integrated
- Typically used when cooling during cold weather AND air economizer impractical
- Does not introduce air-side contaminants or excessively dry winter outside air, as air economizers may do.

- Code Requirement:
  - No mandatory requirement
  - Alternative to air Economizer IF capable of meeting 100% of the expected system cooling load at outside air temperatures of 50°F (10°C) dry bulb/45°F (7°C) wet bulb and below.

Water-side Economizer:

Water-side Economizer must be inspected & verified for proper operation as part of Progress Inspections.
In this section you will learn about:

- Schematics, pros, cons and requirements for Two-pipe systems, Three-pipe systems, Hydronic Heat Pump loop, Primary / Secondary Loops;

- Part-load control requirements including control valve types, pump speed controls and temperature based reset controls; and

- Pump control requirements.
What is a two-pipe hydronic system?

**Two-pipe Changeover Systems:**
- One coil is used for heating or cooling (supply pipe + return pipe) at terminal device.
- Changeover required between chilled water and hot water.
  - Less expensive than four pipe, but
  - Less flexible
    » All zones are provided **either** heating **OR** cooling
- **Code Requirements:**
  - Deadband of 15°F between heating and cooling modes based on OA temperature.
  - 4-hour delay before changing modes
  - **AND**
  - Difference between changeover temperatures must be no more than 30°F
  - **Intent:** To avoid heating previously chilled water or cooling previously heated water.
What is a two-pipe hydronic system?

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- One coil is used for heating or cooling (supply pipe + return pipe) at terminal device
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- 4-hour delay before changing modes
  - AND
  - Difference between changeover temperatures must be no more than 30°F

**Intent:** To avoid heating previously chilled water or cooling previously heated water

These systems also may not provide the same level of comfort during the swing seasons when heating and cooling maybe be required in different parts of a building or at different times of the day.
**Three–pipe Systems:**

- HW (Hot Water) & CHW (Chilled Water) supply available any time to each terminal
- Common (mixed) return

- **Pros:**
  - Less expensive than Four-pipe
  - More flexible than Two-pipe

- **Cons:**
  - Simultaneous heating & cooling due to mixed return

SPECIFICALLY PROHIBITED BY CODE
Water Source Heat Pump Loop:

- Loop circulates water between each water-to-air Water-Source Heat Pump (WSHP) on the system.
- WSHPs extract heat (heating mode) or reject heat (cooling mode) to the loop.
- Water Heater and Heat Rejection Device maintain the loop within temperature limits.

- **Code Requirements:**
  - Two-position (open-closed) valves for each heat pump on a system with a circulating pump > 10HP.
  - Deadband of 20°F between maximum and minimum loop temperature.
    » Exception for controls that “can determine the most efficient operating temperature based on real-time conditions of demand and capacity…”
6. Hydronic Systems

What is a water-source heat-pump loop?

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  » Exception for controls that “can determine the most efficient operating temperature based on real-time conditions of demand and capacity…”

Water-Source Heat-Pump Loop

These valves are also referred to as “snap” valves, because they snap open when compressor is running and then snap closed when the compressor shuts off.

Typical temperatures are 85°F maximum and 65°F minimum. A broader deadband means less energy consumed for heat rejection and water heating, but the WSHPs may operate less efficiently.

A lower maximum temperature means more efficient WSHPs in cooling mode, but more energy consumed by the heat rejection device.

A higher minimum temperature means more efficient WSHPs in heating mode, but more energy consumed by the water heater.
Hydronic Systems

6. Hydronic Systems

What are heating and cooling plant requirements?

Chiller and Boiler Plants:

- Part-Load Control for plants > 300,000 Btu/h design output capacity
  - Reset supply water temp. by 25% of design temp. difference based on return water OR outside air temperature.
  - Reduce pump flow by 50% automatically using:
    » Adjustable speed pumps
    » Multi-staged pumps that reduce total pump horsepower by at least 50%

- Multiple boilers, and chillers in parallel
  - Automatic controls that reduce plant flow when a chiller/boiler turns off

Boiler Plant Specific Requirements:

- Multiple-packaged boiler plants must have controls that automatically sequence the boiler operation; and
- Single boiler plants > 500,000 Btu/h design input capacity must have a multi-staged or modulating burner

Isolation Valves, two-position valves, temperature reset sequences, pump control strategy must be shown on drawings. A minimum sample of 20% must be inspected/tested.
Hydronic Systems

6. Hydronic Systems

What are heating and cooling plant requirements?

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**Boiler Plant Specific Requirements:**
- Multiple-packaged boiler plants must have controls that automatically sequence the boiler operation; and
- Single boiler plants > 500,000 Btu/h design input capacity must have a multi-staged or modulating burner

While typical for boiler plants, this is not often done for chiller plants. For typical chiller systems this would represent about 2.5 to 3F of reset.

Most boiler plant controls have reset based on OA from 180F down to 150F. This is typically much more than the code requirement even for systems with as much as a 40F design temperature difference ... which is larger than most typical designs.

Lower HW (higher CHW) supply water temperatures reduce conduction losses through distribution pipes and can increase boiler (chiller) equipment plant operating efficiency, but can result in increased pump flow.

Chillers piped in series to achieve increased temperature difference are considered a single chiller.
Hydronic Systems

6. Hydronic Systems

How is flow controlled by pumps in a Hydronic Loop?

Pump Speed Controls:

- **Constant Speed Pump Motor**
  - Provide constant flow at constant input power
  - Multiple pumps in parallel can be staged on/off to achieve variable flow control

- **2-Speed Pumps**
  - Provide constant flow at each speed
  - Pump speed changes to achieve variable flow control - based on pressure ranges or flow measurements

- **Variable Speed Pumps**
  - Pump speed continuously modulates to maintain desired static pressure set point

- **Static Pressure**
  - Differential static pressure is set based on Testing, Adjusting & Balancing (TAB) to ensure flow at “remote” terminal devices
  - Static pressure set-point can be reduced based on zone valve position with a DDC systems, but this is not required by Code.

Pump Laws/Formulas

- Pump Speed $\propto$ Water Flow
- Water Pressure $\propto$ $(\text{Water Flow})^2$
- Water Power $\propto$ $(\text{Water Flow})^3$
- Pump Power $\propto \frac{\text{Flow \times Pressure}}{\text{Pump Efficiency}}$

Pump VFD
Hydronic Systems

6. Hydronic Systems

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\]

\[
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\]

\[
\text{Pump Power } \propto \frac{\text{Flow} \times \text{Pressure}}{\text{Pump Efficiency}}
\]

Devices are remote in terms of pressure drop between pump and device. It is possible that devices that are physically closer to the pump have higher pressure drop (i.e., are more hydrostatically remote) than devices located farther from the pumps.
Hydronic System Controls

How is flow controlled at Terminal Units in a Hydronic Loop?

Loop Flow Controls:

- **2-Way Valves at Terminal Units**
  - 2-way valves reduce flow to the terminal device, reducing coil capacity/output
  - System pressure increases with decreasing flow allowing system pumps to reduce flow/speed

- **3-Way Valves at Terminal Units**
  - 3-way valves reduce flow by bypassing unneeded design flow around terminal device
  - Overall system flow remains constant at design flow

- **2-Position Valves**
  - Valves open and close providing 100% of design flow as needed
  - System pressure increases as valves close, allowing system pumps to reduce flow/speed

VFD & pump control strategy, including isolation valves, terminal device valves, temperature reset sequences, pressure sensors, must be shown on drawings.

A minimum 20% sample of pump speed control devices must be inspected/tested.
**Hydronic System Controls**

**6. Hydronic Systems**

**How is flow controlled at Terminal Units in a Hydronic Loop?**

### Loop Flow Controls:

- **2-Way Valves at Terminal Units**
  - 2-way valves reduce flow to the terminal device, **reducing** coil capacity/output
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  - Overall system flow remains constant at design flow

- **2-Position Valves**
  - Valves open and close providing 100% of design flow as needed
  - System pressure increases as valves close, allowing system pumps to reduce flow/speed

A Differential Pressure (DP) sensor is required to set and control the system pressure for flow control. As valves close pressure increases and pumps stage on/off or pump speed is reduced.

Often a 3-way valve is placed at remote terminal devices to reduce system response time changing space demands ... hot/chilled water is maintained throughout the system.
In this section you will learn about:

- Performance Requirements;
- Control Requirements;
  - Temperature
  - Heat Traps
  - Hot Water System Controls
- Pipe Insulation; and
- Swimming Pools.
7. Service Water Heating

Determine performance requirement for Service Hot Water Heater

Refer to Table 504.2

- Multiple fuels, equipment types, equations & rating standards

**Electric:**
- Resistance Water Heaters
- Heat Pump Water Heaters

**Natural Gas:**
- Storage Water Heaters
- Instantaneous Water Heaters
- Boilers

**Oil:**
- Storage Water Heaters
- Instantaneous Water Heaters
- Boilers

**Dual Fuel: Gas & Oil:**
- Boilers

<table>
<thead>
<tr>
<th>Q</th>
<th>Input Rate</th>
<th>Btu/h</th>
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<tbody>
<tr>
<td>SL</td>
<td>Standby Loss</td>
<td>Btu/h</td>
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<tr>
<td>V</td>
<td>Volume</td>
<td>Gallons</td>
</tr>
<tr>
<td>EF</td>
<td>Energy Factor</td>
<td>%</td>
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<tr>
<td>Et</td>
<td>Efficiency (Thermal)</td>
<td>%</td>
</tr>
<tr>
<td>COP</td>
<td>Coefficient Of Performance</td>
<td>-</td>
</tr>
</tbody>
</table>

Standby Loss (SL) and Energy Factors (EF) are provided by the manufacturer. The NYC ECC (Table 504.2) and ASHRAE 90.1 (Table 7.8) include formulas to calculate the efficiency requirements. These formulas vary by type of equipment, but are based on the rated volume of the tank (V) in gallons, and in the case of gas and oil fired heaters are also based on the nameplate input rate input (Q) in Btu/h.

Note also that gas and oil fired equipment includes requirements for thermal efficiency AND standby loss.

For example:

**Electric**
- \( Q \leq 12\text{Kw}, \geq 20\text{ gal:} \)
  \[
  EF = 0.93 - 0.00132 \times V
  \]

**Storage Water heater, Gas**
- \( > 75,000\text{Btu/h}, < 4,000 \text{ (Btu/h)/gal} \)
  \[
  SL = Q/800 + 110 \times \sqrt{V}
  \]
Temperature Controls:
- Allow 110°F for dwelling units
- Allow 90°F for other occupancies
- Public restrooms, maximum allowed temperature is 110°F

Heat Traps:
- **Non-Circulating Systems**
  - Built in at equipment
  - OR
  - Built into supply & discharge piping loops around equipment

System Controls:
- **Circulating Systems**
  - Automatic or manual shut-off for circulating pump during periods when system not in use

Temperature Controls: 504.3; Heat Traps: Table 504.4; System Controls: 504.6
Insulation Requirements

7. Service Water Heating

Which components need to be insulated in Service Hot Water Systems?

Pipe Insulation:

- Circulating systems:
  - 1 in. thickness
- Non-circulating systems:
  - ½ in. thickness for first 8 feet if there are no integral heat traps with heater

(Un insulation thickness based on conductivity 0.27 Btu-in. /h-ft²-°F or less)

Unfired Storage Tanks Insulation:

- R-12.5 or higher

Swimming Pool Cover:

- All heated pools
  - Vapor-retardant cover installed at or on water surface
- Pools heated to over 90°F
  - Cover shall be R-12 or higher
### Pool:

- **Heater Performance**
  - Gas- or oil-fired heaters: 78% Et
  - Heat Pump heaters: 4.0 COP
  - Continuously burning pilots prohibited

- **Heater and Pump Controls**
  - Heater to have readily accessible on-off control independent of thermostat setting
  - Automatic time switches must be installed on heater and pumps
    - Exceptions:
      - Public health standards require 24-hour pump operation
      - Pumps required to operate for solar or site-recovered heat
## 8. Submissions & Inspections

### Learning Objectives

In this section you will learn about:

- HVAC- and SHW-related requirements for NYCECC Submissions, including:
  - Energy Analysis, and
  - Supporting Documentation

- Applicable Progress Inspections associated with HVAC and SHW Systems.
8. Submissions & Inspections  What are the application requirements related to the NYCECC?

Per 1 RCNY §5000-01:

- A Professional Statement
- An Owner Statement
- An Energy Analysis
- Supporting Documentation, including the requirement for and description of Progress Inspections in drawings

This HVAC Module addresses only Energy Analysis, Supporting Documentation, and Progress Inspection issues. A full overview of the required submission documents, including Professional and Owner Statements, is included under the NYCECC Administrative Overview module in this series.
Per 1 RCNY §5000-01:

- Tabular Analysis
- COMcheck software
- Energy Modeling
- Alternative Formats
Option 1: Tabular Analysis

- The Tabular Analysis compares proposed values of each ECC-regulated item in the scope of work with the respective prescriptive values required by the Code.
  - Applicable to New Buildings, Additions, or Alterations
  - Demonstrates Prescriptive Compliance
  - Can be used with either NYCECC or ASHRAE 90.1
### Sample Tabular Analysis - 1

**8. Submissions & Inspections**

**Example of Tabular Analysis for Commercial Alterations / Renovations**

<table>
<thead>
<tr>
<th>NYCECC Citation</th>
<th>Provision</th>
<th>Item Description</th>
<th>Proposed Design Value</th>
<th>Code Prescriptive Value</th>
<th>Supporting Documentation</th>
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<tbody>
<tr>
<td><strong>503.2</strong></td>
<td><strong>Mandatory Provisions</strong></td>
<td></td>
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<tr>
<td>503.2.1</td>
<td>Calculation of heating and cooling loads</td>
<td>Minimum and maximum temperatures for interior design load calculations</td>
<td>N/A</td>
<td>ASHRAE/ACCA 183 ASHRAE HVAC Systems and Equipment Handbook, chapter 3 Energy Code</td>
<td>Signed and Sealed statement from Engineer certifying compliance with energy code</td>
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<tr>
<td>503.2.2</td>
<td>Equipment and system sizing</td>
<td>Heating and cooling equipment shall not exceed calculated loads</td>
<td>Heating and cooling equipment shall not exceed calculated loads</td>
<td></td>
<td>Signed and Sealed statement from Engineer certifying compliance with energy code</td>
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<td><strong>503.2.3</strong></td>
<td><strong>HVAC Equipment Performance Requirements</strong></td>
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<tr>
<td>Table 503.2.3(1)</td>
<td>Unitary air conditioners, condensing units, electrically operated, minimum efficiency requirements</td>
<td>Split System 5 ton air cooled AC unit, AC-1</td>
<td>12.0 EER</td>
<td>11.2 EER</td>
<td>Split System AC units schedule, drawing M-300</td>
</tr>
<tr>
<td>Table 503.2.3(1)</td>
<td>Through the Wall AC unit, 1 ton, AC-2</td>
<td>12.5 SEER</td>
<td>12.0 SEER</td>
<td>Through the wall AC units schedule, drawing M-300</td>
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<tr>
<td>Table 503.2.3(2)</td>
<td>Unitary and applied heat pumps, electrically operated, minimum efficiency requirements</td>
<td>3 ton air cooled heat pump, single package, HP-1</td>
<td>13.2 SEER</td>
<td>13.0 SEER</td>
<td>AC units schedule, drawing M-300</td>
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<td>Table 503.2.3(3)</td>
<td>Packaged Terminal Air Conditioners and Packaged Terminal Heat Pumps</td>
<td>PTAC (Cooling Mode) Replacement, 12,000 BTU, PTAC-1</td>
<td>9.8 EER</td>
<td>10.9-(12000/1000) EER=8.344 EER</td>
<td>PTAC AC units schedule, drawing M-301</td>
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<td>Table 503.2.3(4)</td>
<td>Warm air furnaces and combination warm air furnaces/air-conditioning units, warm air duct furnaces and unit heaters</td>
<td>N/A</td>
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<td>Table 503.2.3(5)</td>
<td>Boilers, Gas and Oil Fired</td>
<td>Oil fired, 250,000 Btu input, B-1</td>
<td>82% AFUE</td>
<td>80% AFUE</td>
<td>Boiler schedule, drawing M-301</td>
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<td>Table 503.2.3(6)</td>
<td>Condensing Units, Electrically operated</td>
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<td>N/A</td>
<td>Table 503.2.3(6)</td>
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<td><strong>Building Mechanical Systems</strong></td>
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<td><strong>503.2 Mandatory Provisions</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>503.2.1 Calculation of heating and cooling loads</td>
<td>Minimum and maximum temperatures for interior design load calculations</td>
<td></td>
<td></td>
<td>Signed and Sealed statement from Engineer certifying compliance with energy code</td>
<td></td>
</tr>
<tr>
<td>503.2.2 Equipment and system sizing</td>
<td>Heating and cooling equipment shall not exceed calculated loads</td>
<td></td>
<td></td>
<td>Signed and Sealed statement from Engineer certifying compliance with energy code</td>
<td></td>
</tr>
<tr>
<td><strong>503.2 HVAC Equipment Performance Requirements</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Table 503.2.3(1) Unitary air conditioners, condensing units, electrically operated, minimum efficiency requirements</td>
<td>Split System 5 ton air cooled AC unit, AC-1</td>
<td>12.0 EER</td>
<td>11.2 EER</td>
<td>Split System AC units schedule, drawing M-300</td>
<td></td>
</tr>
<tr>
<td>Table 503.2.3(1) Unitary air conditioners, condensing units, electrically operated, minimum efficiency requirements</td>
<td>Through the Wall AC unit, 1 ton, AC-2</td>
<td>12.5 SEER</td>
<td>12.0 SEER</td>
<td>Through the wall AC units schedule, drawing M-300</td>
<td></td>
</tr>
<tr>
<td>Table 503.2.3(2) Unitary and applied heat pumps, electrically operated, minimum efficiency requirements</td>
<td>3 ton air cooled heat pump, single package, HP-1</td>
<td>13.2 SEER</td>
<td>13.0 SEER</td>
<td>AC units schedule, drawing M-300</td>
<td></td>
</tr>
<tr>
<td>Table 503.2.3(3) Packaged Terminal Air Conditioners and Packaged Terminal Heat Pumps Replacement, 12,000 BTU, PTAC-1</td>
<td>PTAC (Cooling Mode)</td>
<td>9.8 EER</td>
<td>10.9-(12000/1000) EER=8.344 EER</td>
<td>PTAC AC units schedule, drawing M-301</td>
<td></td>
</tr>
<tr>
<td>Table 503.2.3(4) Warm air furnaces and combination warm air furnaces/air-conditioning units, warm air duct furnaces and unit heaters</td>
<td></td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Table 503.2.3(5) Boilers, Gas and Oil Fired</td>
<td>Oil fired, 250,000 Btu input, B-1</td>
<td>82% AFUE</td>
<td>80% AFUE</td>
<td>Boiler schedule, drawing M-301</td>
<td></td>
</tr>
<tr>
<td>Table 503.2.3(6) Condensing Units, Electrically operated</td>
<td></td>
<td>N/A</td>
<td></td>
<td>Table 503.2.3(6)</td>
<td></td>
</tr>
</tbody>
</table>

---

**Applicants must include reference to the applicable Supporting Documentation for EACH item within the Tabular Analysis.**
### Sample Tabular Analysis - 2

#### 8. Submissions & Inspections

**Example of Tabular Analysis for Commercial Alterations / Renovations**

<table>
<thead>
<tr>
<th>NYCECC Citation</th>
<th>Provision</th>
<th>Item Description</th>
<th>Proposed Design Value</th>
<th>Code Prescriptive Value</th>
<th>Supporting Documentation</th>
</tr>
</thead>
<tbody>
<tr>
<td>503.4.5.1</td>
<td>Single duct VAV system, terminal devices</td>
<td>N/A</td>
<td>N/A</td>
<td>Terminal devices shall be capable of reducing primary supply air before reheating or recooling takes place</td>
<td>N/A</td>
</tr>
<tr>
<td>503.4.5.2</td>
<td>Dual duct and mixing VAV systems, terminal devices</td>
<td>N/A</td>
<td>N/A</td>
<td>Terminal devices shall be capable of reducing air from one duct to a minimum before mixing takes place</td>
<td>N/A</td>
</tr>
<tr>
<td>503.4.5.3</td>
<td>Single fan dual duct and mixing VAV systems, economizers</td>
<td>N/A</td>
<td>N/A</td>
<td>Individual dual duct or mixing heating and cooling systems with a single fan and capacities greater than 90,000 Btu/h shall not be equipped with air economizers</td>
<td>N/A</td>
</tr>
<tr>
<td>503.4.5.4</td>
<td>VAV System with Multiple Zone, supply-air temperature reset controls*</td>
<td>N/A</td>
<td>N/A</td>
<td>Control system shall automatically reset supply-air temperature in response to building load or O.A. temperature</td>
<td>N/A</td>
</tr>
<tr>
<td>503.4.5.6</td>
<td>Heat Recovery for Service Water Heating for systems*</td>
<td>N/A</td>
<td>N/A</td>
<td>Provide condenser water heat recovery, required for 24 hr/day operations, with water cooled systems over 6 million btu/h.</td>
<td>N/A</td>
</tr>
<tr>
<td>503.4.7, table 503.4.7</td>
<td>Hot Gas Bypass Limitation</td>
<td>N/A</td>
<td>N/A</td>
<td>Hot gas bypass is allowed only on systems with multiple steps of unloading or continuous capacity modulation. Allowed Bypass capacity per table 503.4.7</td>
<td>N/A</td>
</tr>
</tbody>
</table>

### 504 Service Water Heating

| 504.2 | Equipment Performance Efficiency | Domestic Water Heater, DWH-1 | 80% Et, instantaneous Gas, 210,000 Btu/h | Shall meet efficiency requirements of table 504.2 | See plumbing schedules, drawing P-300 |
| 504.3 | Temperature Controls | Temperature Controls | Holby Valve, mixed water temperature set for 90 degrees F | Controls shall allow 110 degree F set point for dwellings, and 90 degrees F for other occupancies. Lavatories in public restrooms shall be limited to 110 degrees F | See plumbing schedules, drawing P-300 |
| 504.4 | Heat Traps | N/A | N/A | Water heating equipment shall be provided with heat traps on the supply and discharge piping if not integrated with equipment | N/A |
| 504.5 | Pipe Insulation | Pipe Insulation | 1" insulation shall be used on all hot water service piping | Automatic circulating hot water systems-1" insulation. First 8' pipe in non-circulating systems without integral heat traps-0.5" insulation. Conductivity for insulation shall not exceed 0.27 Btu/inch²/hr°F | See plumbing specification drawings, P-500 |
Option 2: COMcheck submissions

- COMcheck software, available for free from the US Department of Energy, can be used to prepare energy code compliance calculations.
  - Lists all Mandatory and Prescriptive Compliance requirements related to HVAC and SHW systems
  - Only New York State NYCECC or ASHRAE-90.1 COMcheck forms are permitted (not IECC)
  - Downloads: http://www.energycodes.gov/software.stm
Section 3: Mechanical Systems List

<table>
<thead>
<tr>
<th>Quantity</th>
<th>System Type &amp; Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>AC-1 HVAC unit (Single Zone): Heating: 1 each - Central Furnace, Gas, Capacity = 648 kBu/h, Efficiency = 89.00% Ec Cooling: 1 each - Rooftop Package Unit, Capacity = 301 kBu/h, Efficiency = 10.10 EER, Air-Cooled Condenser, Air Economizer</td>
</tr>
<tr>
<td>1</td>
<td>AHU-1 (Multiple-Zone): Heating: 1 each - Hydronic or Steam Coil, Hot Water, Capacity = 295 kBu/h Cooling: 1 each - Hydronic Coil, Capacity = 296 kBu/h, Water Economizer</td>
</tr>
<tr>
<td>1</td>
<td>AC-2/CU-2 (Single Zone): Cooling: 1 each - Split System, Capacity = 18 kBu/h, Efficiency = 13.50 SEER, Air-Cooled Condenser</td>
</tr>
<tr>
<td>1</td>
<td>AC-3/CU-3 (Single Zone): Cooling: 1 each - Split System, Capacity = 60 kBu/h, Efficiency = 13.50 SEER, Air-Cooled Condenser, Air Economizer</td>
</tr>
<tr>
<td>1</td>
<td>PTAC-1 (Single Zone): Heating: 1 each - Other, Hot Water, Capacity = 12 kBu/h Cooling: 1 each - Packaged Terminal Unit, Capacity = 10 kBu/h, Efficiency = 11.20 EER, Air-Cooled Condenser</td>
</tr>
<tr>
<td>1</td>
<td>HP-1 (Single Zone): Packaged Terminal Heat Pump Heating Mode: Capacity = 16 kBu/h, Efficiency = 2.96 COP Cooling Mode: Capacity = 10 kBu/h, Efficiency = 11.25 EER</td>
</tr>
<tr>
<td>1</td>
<td>FUR-1 (Single Zone): Heating: 1 each - Duct Furnace, Gas, Capacity = 43 kBu/h, Efficiency = 85.00% Ec</td>
</tr>
<tr>
<td>1</td>
<td>ASHP-1 (Single Zone): Split System Heat Pump Heating Mode: Capacity = 87 kBu/h, Efficiency = 3.32 COP Cooling Mode: Capacity = 100 kBu/h, Efficiency = 11.20 EER, Air Economizer</td>
</tr>
</tbody>
</table>

All HVAC systems and details should use the same identification and keying in the Energy Analysis and the Supporting Documentation (Drawings and Schedules) for clear cross-reference.
Option 3: Energy Cost Budget Worksheet

- Either NYCECC Section 506 or the Energy Cost Budget Method of ASHRAE 90.1 can be used to demonstrate compliance.
  - Applicable to New Buildings, Additions, or Alterations
  - Requires computer energy modeling, using software programs approved by the Secretary of State of New York State and the NYC Commissioner of Buildings (e.g., DOE-2.1E, VisualDOE, Energy Plus, eQuest)
  - Compliance is demonstrated using the EN1 form
**Input information in this form should be reflected in the Supporting Documentation to the permit application.**

### Heating, Ventilating & Air Conditioning

<table>
<thead>
<tr>
<th>Description</th>
<th>EN1 Details</th>
<th>SHW Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Refrigeration equipment type</td>
<td>Air cooled Chiller with multiple compressors, EER = 9.4</td>
<td>Air cooled, packaged DX units EER = 9.3-10.3</td>
</tr>
<tr>
<td>Heating equipment type</td>
<td>82% efficient boiler w/ modulating flame controls</td>
<td>80% efficient boiler w/ on-off controls</td>
</tr>
<tr>
<td>Demand controlled ventilation</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>Economizer type (air or water)</td>
<td>air/water</td>
<td>none</td>
</tr>
<tr>
<td>Domestic hot water heating source</td>
<td>Dual Fuel DWH heater</td>
<td>Natural Gas DWH heater</td>
</tr>
</tbody>
</table>
The overall regulated annual energy use and annual energy cost of the Proposed and Budget building designs are summarized at the end of the EN1 form, and this is where compliance or non-compliance is demonstrated.
Supporting Documentation should:

- Support the values submitted in the Energy Analysis;
- Verify mandatory requirements of the NYCECC are met; and
- Provide a listing and description of the applicable progress inspections required based on the scope of work of the project.

HVAC and SHW documentation should include:

- **ALL** plans, details, notes, and sequences of operation demonstrating that systems, equipment, components, and control sensors meet performance and operating requirements as developed in the Energy Analysis.
Supporting Documentation for HVAC and SHW:

- **Floor plans showing:**
  - Terminal Units
  - Controls
  - Duct work and piping
  - HVAC equipment

- **Mechanical schedules showing:**
  - HVAC equipment (terminal units, pumps, fans, energy recovery)
  - Design operating temperatures
  - Performance values (flow rates, efficiencies, nhp)

- **Equipment details showing:**
  - Coils, terminal units, including:
    - Valves
    - Dampers
    - Sensors

- **Control diagrams showing:**
  - Sequences of operation with operating set-points
  - Control valves, dampers and sensors
The following Sample Supporting Documentation has been developed to illustrate compliance procedures related to the NYCECC only. Additional Information required by the DOB related to zoning and other code provisions is intentionally omitted.
Controls need to be shown and HVAC equipment clearly marked in the plans of the Supporting Documentation.
Schedules shall clearly indicate performance values, and provide sufficient information to confirm compliance with NYCECC requirements.
Mechanical Details

Details need to show control and balancing features.
Features with different names may perform the same function with respect to code compliance. For example, a “circuit setter” and “plug valve with locking flow plate” serve the purpose of both balancing valves.

Details need to show control and balancing features.
Sample Supporting Documentation

8. Submissions & Inspections

ENERGY CODE COMPLIANCE NOTES:

All energy code compliance notes shall be printed in a format and size that allows for easy readability and referencing. These notes shall be included in the documentation provided for the project. They shall be referenced in accordance with the Energy Analysis.

Notes shall contain Code requirements not shown elsewhere in documents. Note number and drawings should be indexed/referenced to Code citation in the Energy Analysis.

Mechanical/Energy Code Compliance Notes
Confirm that the Energy Code compliance path is consistent with the rest of the application, and be sure to check-off the applicable Certification Requirements in the COMcheck Summary.

Sign and Seal either the title block or the COMcheck Summary as appropriate.
## Sample Progress Inspection List

### 8. Submissions & Inspections

<table>
<thead>
<tr>
<th>Inspection/Test</th>
<th>Frequency (minimum)</th>
<th>Reference Standard (See ECC Chapter 6) or Other Criteria</th>
<th>ECC or Other Citation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>IIB Mechanical and Service Water Heating Inspections</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>IIB1 Fireplaces</strong>: Provision of combustion air and tight-fitting fireplace doors shall be verified by visual inspection.</td>
<td>Prior to final construction inspection</td>
<td>Approved construction documents; ANSI Z21.60 (see also MC 904), ANSI Z21.50</td>
<td>303.1.5; BC 2111; MC Chapters 7, 9; FGC Chapter 6</td>
</tr>
<tr>
<td><strong>IIB2 Outdoor air intakes and exhaust openings</strong>: Dampers for stair and elevator shaft vents and other outdoor air intakes and exhaust openings integral to the building envelope shall be visually inspected to verify that such dampers, except where permitted to be gravity dampers, comply with approved construction drawings. Manufacturer’s literature shall be reviewed to verify that the product has been tested and found to meet the standard.</td>
<td>As required during installation</td>
<td>Approved construction documents; AMCA 500D</td>
<td>502.4.4</td>
</tr>
<tr>
<td><strong>IIB3 HVAC, service water heating and pool equipment sizing and performance</strong>: Equipment sizing, efficiencies and other performance factors of all major equipment units, as determined by the applicant of record, and no less than 15% of minor equipment units, shall be verified by visual inspection and, where necessary, review of manufacturer’s data. Pool heaters and covers shall be verified by visual inspection.</td>
<td>Prior to final plumbing and construction inspection</td>
<td>Approved construction documents</td>
<td>503.2, 504.2, 504.7</td>
</tr>
<tr>
<td><strong>IIB4 HVAC system controls and economizers and service hot water system controls</strong>: No less than 20% of each type of required controls and economizers shall be verified by visual inspection and tested for functionality, such testing shall be performed by the inspection personnel.</td>
<td>After installation and prior to final electrical and construction inspection, except that for controls with seasonally dependent functionality, such testing shall be performed by the inspection personnel.</td>
<td>Approved construction documents, including control system narratives; ASHRAE Guideline 1: The HVAC Commissioning Process,</td>
<td>503.2.4, 503.2.5.1, 503.2.11, 503.3, 503.4, 504.3, 504.6, 504.7</td>
</tr>
<tr>
<td><strong>IIB5 Duct, plenum and piping insulation and sealing</strong>: Insulation placement and values. Joints, longitudinal and transverse seams, and connections shall be visually inspected for proper sealing.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A Progress Inspections Table must be included in the Supporting Documentation drawings, noting all applicable inspections to be performed based on the scope of work, plus Reference Standards and NYCECC Citations. The design applicant must also include contract language requiring the contractor to identify time in the construction schedule for the progress inspections.
### 8. Submissions & Inspections

**What are the applicable progress inspections for HVAC & SHW?**

<table>
<thead>
<tr>
<th>Inspection / Test</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fireplaces</strong></td>
<td>Prior to final construction inspection</td>
</tr>
<tr>
<td>Provision of combustion air and tight-fitting fireplace doors shall be verified by visual inspection.</td>
<td></td>
</tr>
</tbody>
</table>

**Outdoor Air Intakes and Exhaust Openings**

Dampers for stair and elevator shaft vents and other Outdoor Air (OA) intakes and exhaust openings integral to the building envelope shall be visually inspected to verify that such dampers, except where permitted to be gravity dampers, comply with approved construction drawings.

**Manufacturer’s literature shall be reviewed** to verify that the product has been tested and found to meet the standard.

<table>
<thead>
<tr>
<th><strong>HVAC, Service Water and Pool Equipment Sizing</strong></th>
<th>Prior to final plumbing and construction inspection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equipment sizing, efficiencies and other performance factors of all major equipment units, as determined by the applicant of record, and no less than 15% of minor equipment units, shall be verified by visual inspection and, where necessary, review of manufacturer’s data.</td>
<td></td>
</tr>
<tr>
<td>Pool heaters and covers shall be verified by visual inspection.</td>
<td></td>
</tr>
</tbody>
</table>
### Inspection / Test

**HVAC System Controls and Economizers and Service Hot Water System Controls**

No less than 20% of each type of required controls and Economizers shall be **verified by visual inspection and tested** for functionality and proper operation. Such controls shall include, but are not limited to:

- Thermostatic
- Set point overlap restriction
- Off-hour
- Shutoff damper
- Snow-melt system
- Demand control systems
- Outdoor heating systems
- Zones
- Economizers
- Air systems
- Variable air volume fan
- Hydronic systems
- Heat rejection equipment fan speed
- Complex mechanical systems serving multiple zones
- Ventilation
- Energy recovery systems
- Hot gas bypass limitation
- Temperature
- Service water heating
- Hot water system
- Pool heater and time switches
- Exhaust hoods
- Radiant heating systems

Controls with seasonally dependent functionality:

- Controls whose complete operation cannot be demonstrated due to prevailing weather conditions typical of the season during which progress inspections will be performed shall be permitted to be signed off for the purpose of a Temporary Certificate of Occupancy with only a visual inspection, provided, however, that the progress inspector shall perform a supplemental inspection where the controls are visually inspected and tested for functionality and proper operation during the next immediate season thereafter.

The owner shall provide full access to the progress inspector within two weeks of the progress inspector’s request for such access to perform the progress inspection.

For such supplemental inspections, the Department shall be notified by the approved progress inspection agency of any unresolved deficiencies in the installed work within 180 days of such supplemental inspection.

---

**Frequency**

After installation and prior to final electrical and construction inspection, except that for controls with seasonally dependent functionality, such testing shall be performed before sign-off for issuance of a Final Certificate of Occupancy.

---

Reference: 1 RCNY §5000-01
### Inspection / Test

<table>
<thead>
<tr>
<th>Inspection / Test</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Duct, Plenum and Piping Insulation and Sealing</strong></td>
<td>After installation and prior to closing shafts, ceilings and walls</td>
</tr>
<tr>
<td>Installed duct and piping insulation shall be <a href="#">visually inspected to verify proper insulation placement and values</a>.</td>
<td></td>
</tr>
<tr>
<td>Joints, longitudinal and transverse seams and connections in ductwork shall be <a href="#">visually inspected</a> for proper sealing.</td>
<td></td>
</tr>
<tr>
<td><strong>Air Leakage Testing for High-pressure Duct Systems</strong></td>
<td>After installation and sealing and prior to closing shafts, ceilings and walls</td>
</tr>
<tr>
<td>For duct systems designed to operate at static pressures in excess of 3 inches w.g. (746 Pa), <a href="#">representative sections, as determined by the progress inspector, totaling at least 25% of the duct area</a>, per ECC 503.2.7.1.3, <a href="#">shall be tested</a> to verify that actual air leakage is below allowable amounts.</td>
<td></td>
</tr>
</tbody>
</table>
Progress Inspections – TR8 Report

8. Submissions & Inspections

3 Energy Code Progress Inspection

<table>
<thead>
<tr>
<th>Y</th>
<th>N Progress Inspections</th>
<th>Table Reference in 1RCNY §5000-01(h)(1) and (2)</th>
<th>3B Identification of Responsibilities</th>
<th>3C Certificate of Complete Inspections / Tests</th>
<th>3D Withdraw Responsibilities</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Initial &amp; Date</td>
<td>Initial &amp; Date</td>
<td>Initial &amp; Date</td>
</tr>
<tr>
<td></td>
<td>Dampers integral to building envelope</td>
<td>(IB2), (IB2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>HVAC and service water heating equipment</td>
<td>(IB3), (IB3)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>HVAC and service water heating system controls</td>
<td>(IB4), (IB4)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Duct plenum and piping insulation and sealing</td>
<td>(IB5), (IB5)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Duct leakage testing</td>
<td>(IB6), (IB6)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2011 NYCECC
June 2011
The applicant (registered professional) defines the required progress inspections by checking “Y” or “N” in the left-hand column under section 3 of the TR8 form.

Prior to Permit, the designated Progress Inspector must initial and date each inspection they will be responsible for, and sign/seal under section 5 of the TR8 form. If multiple Progress Inspectors are involved in a project, each one must submit a signed/sealed TR8 for their scope of inspection services.
6. Inspection Applicant’s Certification of Completion

☐ I have completed the items specified herein and certify the following (check one only):

☐ All work performed substantially conforms to approved construction documents and has been performed in accordance with applicable provisions of the New York City Energy Conservation Code and other designated rules and regulations.

☐ All work performed substantially conforms to approved construction documents and has been performed in accordance with applicable provisions of the New York City Energy Conservation Code and other designated rules and regulations, except as indicated in the attached report.

I am aware of the additional sanctions imposed on false filings by §28-211.1.2 of the Administrative Code.

☐ Withdrawal of Applicant: I am withdrawing responsibility for the items of progress inspections and/or tests indicated herein and herewith submit the results or status of the work performed to date.

Name (please print) ________________________________

Signature ___________________________ Date ____________

P.E. / R.A. Seal (apply seal, then sign and date over seal)
6. Inspection Applicant’s Certification of Completion

☐ I have completed the items specified herein and certify the following (check one only):

☐ All work performed substantially conforms to approved construction documents and has been performed in accordance with applicable provisions of the New York City Energy Conservation Code and other designated rules and regulations.

☐ All work performed substantially conforms to approved construction documents and has been performed in accordance with applicable provisions of the New York City Energy Conservation Code and other designated rules and regulations.

I am aware of the additional sanctions imposed on false filings by §28-211.1.2 of the Administrative Code.

☐ Withdrawal of Applicant: I am withdrawing responsibility for the items of progress inspection, the results or status of the work performed to date.

Name (please print)

Signature Date

P.E. / R.A. Seal (apply seal, then sign and date over seal)

Upon completion of the applicable inspections, the Progress Inspector initials and dates each inspection performed (column 3C). Any inspections assigned to the Progress Inspector that are not performed are addressed through column 3D (withdraw responsibilities). Final signatures and seals are provided in section 6 of the TR8 form.
Per NYC Administrative Code §28-116.2.3

- A record of all inspections shall be kept by the person performing the inspection.
  - The commissioner can require inspection reports to be filed with the department.
  - Records of inspections shall be maintained for a period of six years after sign-off, or for such other period of time as the commissioner may require.
  - Records of inspections shall be made available to the DOB upon request.

**EN2 Form:**

- This DOB form is signed by the progress inspector, certifying that the values in either the last approved Energy Analysis or in the as-built Energy Analysis represent values in the constructed building.
Progress Inspections – EN2 Form

3 As Built Information

☐ The as-built conditions of the completed building conform to the originally approved energy analysis and do not require a revised energy analysis.

☐ The energy analysis has been revised according to one of the statements below:

☐ Attached is a revised energy analysis, prepared, signed and sealed by the registered design professional who prepared the previously submitted and approved energy analysis. The as-built conditions of the completed building conform to this revised energy analysis.

☐ The last revised energy analysis was submitted and approved as a post approval amendment on _______________________. The as-built conditions of the completed building conform to this revised energy analysis.

Sealed and submitted to:
Name (please print)

Signature
Date

P.E. / R.A. Seal (Apply seal, then sign and date over seal)
The Progress Inspectors and design applicants will need to coordinate to ensure that the as-built conditions and approved energy analysis are consistent. An as-built energy analysis update may be required.
### Abbreviations Key

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAV (or CV)</td>
<td>Constant Air Volume</td>
</tr>
<tr>
<td>CHW</td>
<td>Chilled Water</td>
</tr>
<tr>
<td>COP</td>
<td>Coefficient of Performance</td>
</tr>
<tr>
<td>DB</td>
<td>Dry-Bulb (temperature)</td>
</tr>
<tr>
<td>DDC</td>
<td>Direct Digital Control</td>
</tr>
<tr>
<td>DOB</td>
<td>Department of Buildings</td>
</tr>
<tr>
<td>DX</td>
<td>Direct Expansion</td>
</tr>
<tr>
<td>EER</td>
<td>Energy Efficiency Ratio</td>
</tr>
<tr>
<td>ERV</td>
<td>Energy Recovery Ventilator</td>
</tr>
<tr>
<td>HP</td>
<td>Horse Power (Nameplate)</td>
</tr>
<tr>
<td>HP</td>
<td>Heat-Pump</td>
</tr>
<tr>
<td>BHP</td>
<td>Brake Horse Power</td>
</tr>
<tr>
<td>HVAC</td>
<td>Heating Ventilation &amp; Air Conditioning</td>
</tr>
<tr>
<td>HW</td>
<td>Hot Water</td>
</tr>
<tr>
<td>SHW</td>
<td>Service Hot Water</td>
</tr>
<tr>
<td>DHW</td>
<td>Domestic Hot Water</td>
</tr>
<tr>
<td>IPLV</td>
<td>Integrated Part-Load Value</td>
</tr>
<tr>
<td>NPLV</td>
<td>Non-Standard Part-Load Value</td>
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<tr>
<td>SP</td>
<td>Static Pressure</td>
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<tr>
<td>VAV</td>
<td>Variable Air Volume</td>
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<tr>
<td>VFD</td>
<td>Variable Frequency Drive</td>
</tr>
<tr>
<td>VSD</td>
<td>Variable Speed Drive</td>
</tr>
<tr>
<td>WB</td>
<td>Wet-Bulb (temperature)</td>
</tr>
<tr>
<td>WSHP</td>
<td>Water-Source Heat-Pump</td>
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## Resources and Links

The resources below have been referenced in this module

<table>
<thead>
<tr>
<th>Resource</th>
<th>Link</th>
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<tbody>
<tr>
<td>New York City Construction Codes</td>
<td><a href="http://www2.iccsafe.org/states/newyorkcity/">http://www2.iccsafe.org/states/newyorkcity/</a></td>
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Questions on the NYCECC can be submitted to the DOB at:

Energycode@buildings.nyc.gov
## 12. Resources

<table>
<thead>
<tr>
<th>Company or Individual</th>
<th>Slide Numbers</th>
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<tr>
<td>Samantha Modell</td>
<td>84</td>
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<td><a href="http://www.energysavers.gov">www.energysavers.gov</a></td>
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