

SPECIFICATION FOR EMBEDDED COMMISSIONING CAPABLE HEAT PUMPS AND AIR CONDITIONERS



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ABOUT BETTERBUILT^{NW}

BetterBuiltNW is a resource platform committed to accelerating the adoption of energy-efficient residential building practices. BetterBuiltNW is a core component of the Northwest Energy Efficiency Alliance’s Residential Construction Program.

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1. INTRODUCTION

This specification will be used to establish a method of certification to identify residential heat pumps and air conditioners based on their ability to generate a verification report that the equipment has been properly commissioned. This document is subject to periodic updates as needed. Equipment that meets this specification will be defined as *Embedded Commissioning Capable*. The goal of this specification is to establish a minimum requirement for a product that can report commissioning results and controls at time of installation. A goal is to establish a national registry that hosts a qualified product list (QPL) of embedded commissioning capable products. This list will help utilities and HVAC technicians identify embedded commissioning capable products and thereby avoid loss of longevity and performance caused by inadequate commissioning.

1.1 General Description

Figure 1 provides a conceptual drawing of an Embedded Commissioning system. Manufacturers may choose the method of interface (mobile app or other) and use of either embedded or third-party tools to collect data. It is up to the manufacturer to set the acceptable ranges of refrigerant charge and airflow to determine what is properly commissioned. A properly commissioned system should operate reliably, meet design comfort goals and have charge, airflow and control settings that do not compromise the energy efficiency of the system to the extent practicable. The manufacturer is responsible for defining the operating conditions for a given system, in a given climate and a given design configuration.

Figure 1. Conceptual Drawing of Embedded Commissioning



Embedded Commissioning capabilities may exist on any type of heat pump or air conditioner but are most valuable for variable speed systems which have intrinsically wider operational ranges and generally more sophisticated controls and sensors that make onsite commissioning verification more challenging without some form of guided application and interface.

While each system may be different, the core presumptions of Embedded Commissioning are:

1. A phone-, tablet-, or computer-based app is used to interact with the system being commissioned and provide the contractor with a guided commissioning process.
2. Embedded Commissioning data is uploaded from the system to the manufacturer's cloud system to generate a report that can be forwarded by the installer.
3. Data collection will be conducted digitally, using onboard sensors or third-party wireless sensors, minimizing reliance on contractor manual entry.

1.2 Applicable Products

Included Products: AHRI listed single-phase unitary air conditioners and heat pumps not greater than 65,000 Btu/hr of rated cooling capacity. Single package, split system, and gas/electric package units that meet the definitions of a central air conditioner or heat pump in Section 4. Units may be intended for installation into a duct system or may be ductless.

Partial Exemptions:

1. Ductless systems are exempt from the airflow requirements of this specification.
2. Factory charged and sealed systems are exempt from the refrigerant charge requirements of this specification.

Excluded Products: Three phase central air conditioners and heat pumps, and products with rated capacities greater than 65,000 Btu/h.

1.3 Product Certification

The product certification process will be defined in Appendix A by a collaborative effort between NLR, NEEA, and PNNL. The certification process will consist of third-party evaluation of an Embedded Commissioning system's methodology and ability to report the required information. Embedded Commissioning systems can be tested and certified for whole product lines using the same Embedded Commissioning methodology.

Proprietary information such as OEM methods for measuring or calculating the values required to be reported will be kept confidential to the only the certifying party and parties deemed necessary.

2. EMBEDDED COMMISSIONING REPORT

2.1 Report Summary

An Embedded Commissioning system, regardless of methodology, has the ability to generate a report showing results of the required commissioning metrics.

The Embedded Commissioning Report must include all information deemed essential or

required in this specification. The Embedded Commissioning Report is a digital record in a unique data sharing file (JSON). The Embedded Commissioning Report is intended to provide all commissioning information collected by the Embedded Commissioning process with the content formatted for the specific needs of incentive programs. It is assumed the Embedded Commissioning Report would be different from one created for the installing contractor or homeowner. The Embedded Commissioning Report may contain additional product details and installation information as determined by the manufacturer. Details of the standardized Embedded Commissioning Report are provided in Table 1.

Figure 2. Example Embedded Commissioning Report

Embedded Commissioning Report		Pass, Fail of X (True or False value)
System Information		
Location of Installation	GPS Coordinates	
Completion Date	Month / Day / Year	
AHRI Certification #	Of Matched Pair	
Indoor Unit	Make and Model	
Outdoor Unit	Make and Model	
Thermostat Model	Make and Model	
Efficiency Ratings	HSPF2: SEER2: EER2: 5F Capacity Ratio:	
Suitable Conditions		
Outdoor Temperature	° F	
Indoor Temperature	° F	
Refrigerant Charge Adequacy		
Liquid Line Temperature	° F	
Degrees of Subcooling	° F	
Target Subcooling	° F	
Airflow Adequacy		
Fan Power	W	
Airflow	CFM	
Controller Information		
Auxiliary Heat Lockout	N/A or Off or ° F	
Compressor Lockout	N/A or Off or ° F	
Setback Recovery Mode	N/A or Off or On	
WiFi Connection	Connected or Not Connected	
Load Flex Capability	AHRI 1380, ENERGY STAR Connected Thermostat, Direct Load Control, Relay Switches, Other (list)	
Switchover [Dual Fuel ONLY]	N/A or ° F or Description of Control Method	

2.2 Embedded Commissioning Report Criteria

An Embedded Commissioning capable system must be able to verify the system is properly commissioned according to manufacturer specifications and generate a commissioning report containing all required information.

The Embedded Commissioning Specification does not specify the method used to determine criteria are met. Each manufacturer determines how to do this using a mixture of proxy data or direct measurements. The certification process will verify if the values are accurate and manufacturer tolerances are met. For example, airflow could be achieved using a third-party wireless flow plate array, mapping of fan power draw, the temperature drop across the coil for a given refrigerant flow, or another method. Any approach could be used, providing the equipment can reliably achieve repeatable accuracy of verification across a range of possible commissioning conditions.

Logical data are pass/fail or true/false thresholds defined by the manufacturer or the Embedded Commissioning Specification.

Reported data are required to confirm specific operational or control criteria. These are measured directly or via proxy data using embedded sensors, or third-party tools. Reported values do not have defined thresholds within the specification but may have requirements within programs or code. The goal is to define the expected outcome, not the method employed by the manufacturer.

All data required to be reported is described in Table 1.

Table 1. Embedded Commissioning Report Criteria

Criteria Name	Purpose	Requirement	Criteria	Result
Suitable Conditions	Confirm conditions are suitable to complete Embedded Commissioning.	Commissioning is completed under manufacturer-defined acceptable ambient conditions. Both the minimum and maximum Embedded Commissioning temperatures for both indoor and outdoor conditions are defined by the equipment manufacturer.	Equipment reports outdoor temperature (Toutdoor) and indoor temperature (Tindoor) at time of commissioning and a True or False value that these temperatures are within the acceptable range. 1) Maximum outdoor Embedded Commissioning Temperature $\geq$ Toutdoor $\geq$ Minimum outdoor Embedded Commissioning Temperature 2) Maximum indoor Embedded Commissioning Temperature $\geq$ Tindoor $\geq$ Minimum indoor Embedded Commissioning Temperature	True / False Toutdoor Tindoor
Charge Adequacy	Confirm the refrigerant charge is adequate to deliver acceptable COP.	Commissioning app provides a guided procedure that confirms the system refrigerant charge meets manufacturer specifications. Embedded Commissioning confirms the system refrigerant charge meets manufacturer charge adequacy requirements. Factory charged and sealed systems are exempt from this requirement.	Commissioning app can verify the refrigerant charge has less than 10% effect on COP at test conditions and reports the necessary information listed in the result.	True / False Liquid Line Temperature (measured) Degrees of Subcooling (measured) Target Subcooling (OEM Defined)

Criteria Name	Purpose	Requirement	Criteria	Result
Airflow Adequacy	Confirm the airflow through the indoor unit is adequate to deliver acceptable heating and cooling.	Airflow rate across the indoor coil is reported and is acceptable for the equipment as defined by the OEM. Embedded Commissioning confirms the system airflow meets the manufacturer's airflow requirements. Ductless systems are exempt from this requirement.	Commissioning app can measure airflow rate across the indoor coil. The commissioning app reports this value in CFM and provides a pass if the measured airflow is within the OEM acceptable range or a fail if the measured airflow is outside of the OEM acceptable range.	True / False Fan Power (W) Airflow (CFM) Fan Efficacy (W/CFM)
WiFi Connection	Show connectivity at the time of startup.	Report the WiFi connection status.	The commissioning app reports if the equipment is connected to WiFi or not at the time of commissioning.	Connected / Not Connected
Load Flex Capability	List the load flexibility or demand response protocols the system (heat pump/air conditioner and thermostat combination) is capable of participating in.	Report the system is ready to participate in load flexibility or demand response programs as installed, if connected to the internet.	The commissioning app reports if the equipment is capable of participating in load flexibility or demand response events.	AHRI 1380 Certified ENERGY STAR® Connected Thermostat Direct Load Control Relay Switches Other (list)
Location of Installation	This data is used to associate the installation with the address applying for incentives, permitting, or other.	Report the GPS location of the installed equipment.	The commissioning app reports the location of the installation.	GPS Coordinates
Embedded Commissioning Completion Date	Show the date that Embedded Commissioning was completed.	Report the date the Embedded Commissioning process is completed.	The commissioning app reports the date the Embedded Commissioning process is completed.	Month / Day / Year

Criteria Name	Purpose	Requirement	Criteria	Result
Auxiliary Heat Control	Show the control method of auxiliary heat at the time of installation.	Report the electric resistance lockout and compressor lockout temperatures if applicable.	The commissioning app reports the auxiliary heat lockout and compressor lockout temperatures if applicable.	Auxiliary Heat Lockout (N/A / Off / Temp) Compressor Lockout (N/A / Off / Temp)
Setback Recovery	Show if the equipment has a setback recovery mode that mitigates supplemental heat usage and if the system is configured to operate in this mode.	Report if the system is capable of recovering without relying on excess supplemental heat and if it is configured to operate in this mode.	The commissioning app reports if it is configured to operate in the setback recovery mode that mitigates excessive electric resistance.	Setback Recovery Mode (N/A / Off / On)
Switchover [Dual Fuel ONLY]	Show the switchover temperature or control method used for dual fuel systems.	Report the switchover temperature or control method used if the system is dual fuel.	The commissioning app reports the switchover temperature or control method used.	Switchover (N/A / °F / Description of Control Method)
Equipment Information	List the components of the system installed including indoor unit, outdoor unit, and thermostat. Including the AHRI # of the matched pair.	Report the make and model of the indoor unit(s), outdoor unit, and thermostat and the AHRI # of the configuration.	The commissioning app reports the make and model of the indoor unit(s), outdoor unit, and thermostat and the AHRI # of the product combination.	Indoor Unit Make and Model Outdoor Unit Make and Model Thermostat Make and Model AHRI #

Criteria Name	Purpose	Requirement	Criteria	Result
System Efficiencies	List the efficiencies of the installed equipment.	Report the HSPF2, SEER2, EER2 and Capacity Ratio at 5F of the installed equipment combination.	The commissioning app reports the HSPF2, SEER2, EER2 and 5F Capacity Ratio of the installed equipment combination.	HSPF2 SEER2 EER2 5F Capacity Ratio H1 _{low} test value (optional) H4 _{high} test value (optional)

3. COMMISSIONING GUIDANCE

An intent of Embedded Commissioning is to provide feedback for the installer during the commissioning process. This section outlines the core elements that a good Embedded Commissioning application can provide the installer. This is informative and presented as expectation, not requirement for certification.

An Embedded Commissioning system should provide the installing technician with guidance that includes instructions and support for addressing installation-related equipment inadequacies that are detected during the commissioning process.

A goal of Embedded Commissioning is to provide installers with a step-by-step process to fulfil the requirements of this specification. This includes both the aspects involved in automated system checking and the instances where the installer is asked to report certain data. When possible, the Embedded Commissioning system should have the necessary safeguards to prevent the installer from entering the wrong information.

Commissioning guidance should do the following:

1. Provide a step-by-step procedure for the commissioning process
 - a. Include a step to initiate Embedded Commissioning
2. Identify equipment faults that must be corrected prior to final commissioning
3. Provide recommended actions to resolve equipment faults when possible
4. Provide confirmation list of what equipment is installed
5. Provide confirmation that indoor units are wired correctly
 - a. In multi-head systems, provide a method of identifying locations
6. Provide directions to locate tables of operating data for the specific equipment installed
7. Provide directions to locate equipment specific manuals (installation, service, engineering)
8. Display the commissioning results to the technician that includes:
 - a. All Embedded Commissioning report information
 - b. Warning indicators (such as high static pressure) which while still within the OEM operational limits, may compromise efficient equipment operation
 - c. Other installation information which is relevant to ensure fault-free equipment installation

4. DEFINITIONS AND TERMS

Terms used in this document are defined as specified in section 1 of ENERGY STAR® Version 6.2 Program Requirements and/or section 3 of ANSI/RESNET/ACCA 310-2020.

5. APPENDIX A:

EMBEDDED COMMISSIONING CERTIFICATION PROCESS

This Appendix is in development and shown for reference of the reviewer. A completed version will be included with the final version of the Specification.

This section provides a general description of the future method to be developed by NLR, PNNL, ORNL in collaboration with the OEM technical working group to certify an Embedded Commissioning system.

When properly used, an Embedded Commissioning system can accurately provide these functions under a wide range of conditions:

1. Documentation of system, settings, and conditions in which it was commissioned
2. Verification of certification report that confirms the system met manufacturer requirements for proper commissioning

The certification process consists of a third-party review of each of the specification requirements. This is broken down into the following four reviews:

1. Documentation review
2. Performance Criteria review
3. Non-Performance Criteria review
4. Report Generation review

5.1 Documentation Review

The documentation review is a review of the documentation delivered with the Embedded Commissioning system.

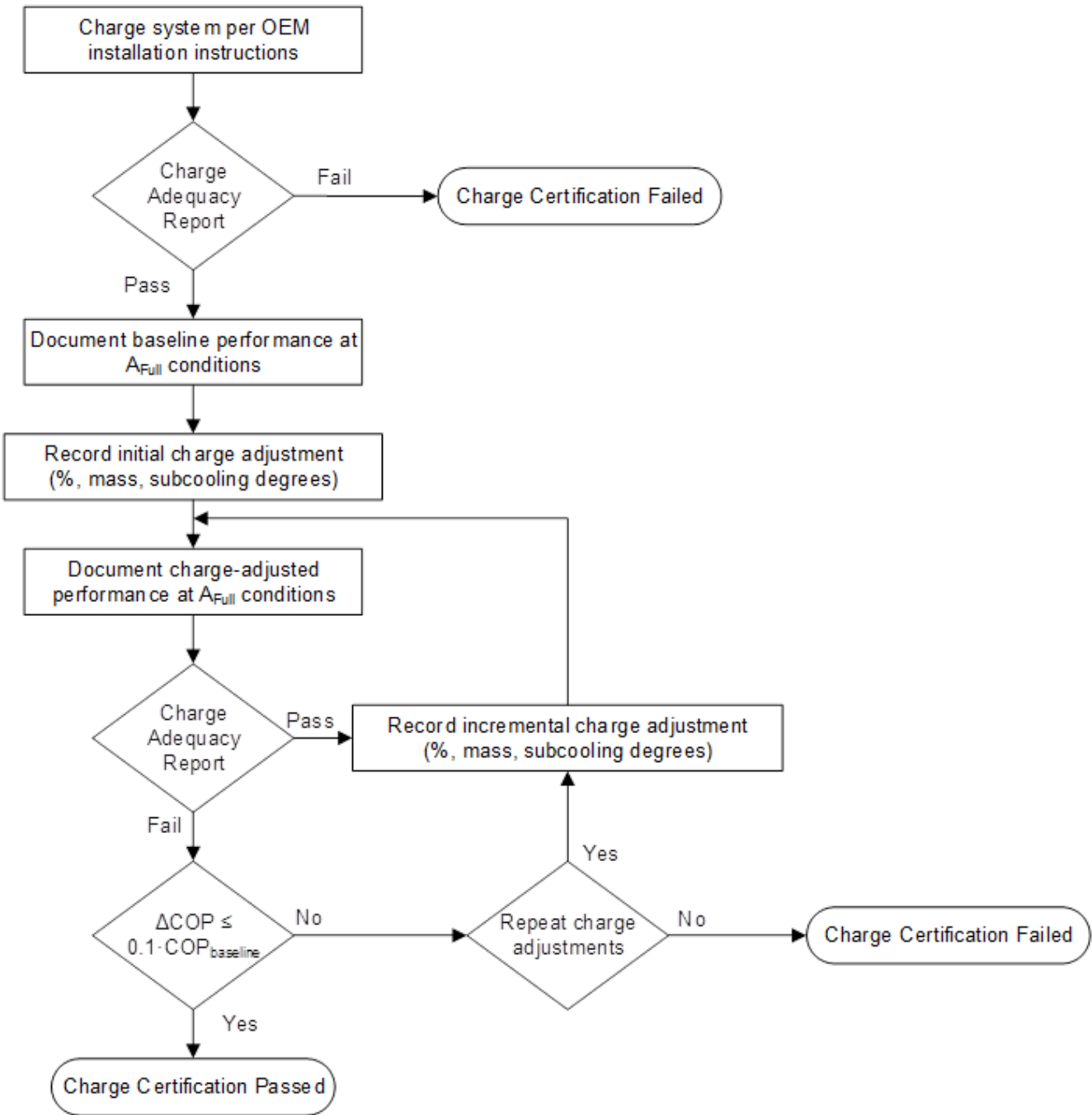
5.2 Performance Criteria Review

The performance criteria review is a review of the charge adequacy and airflow adequacy requirements. To pass, the Embedded Commissioning system must pass the charge adequacy and airflow adequacy certification processes shown in 3.2.1 and 3.2.2.

5.3 Charge Adequacy Certification Process Flowchart

Provided here for reference – see Embedded Commissioning certification document for accompanying details

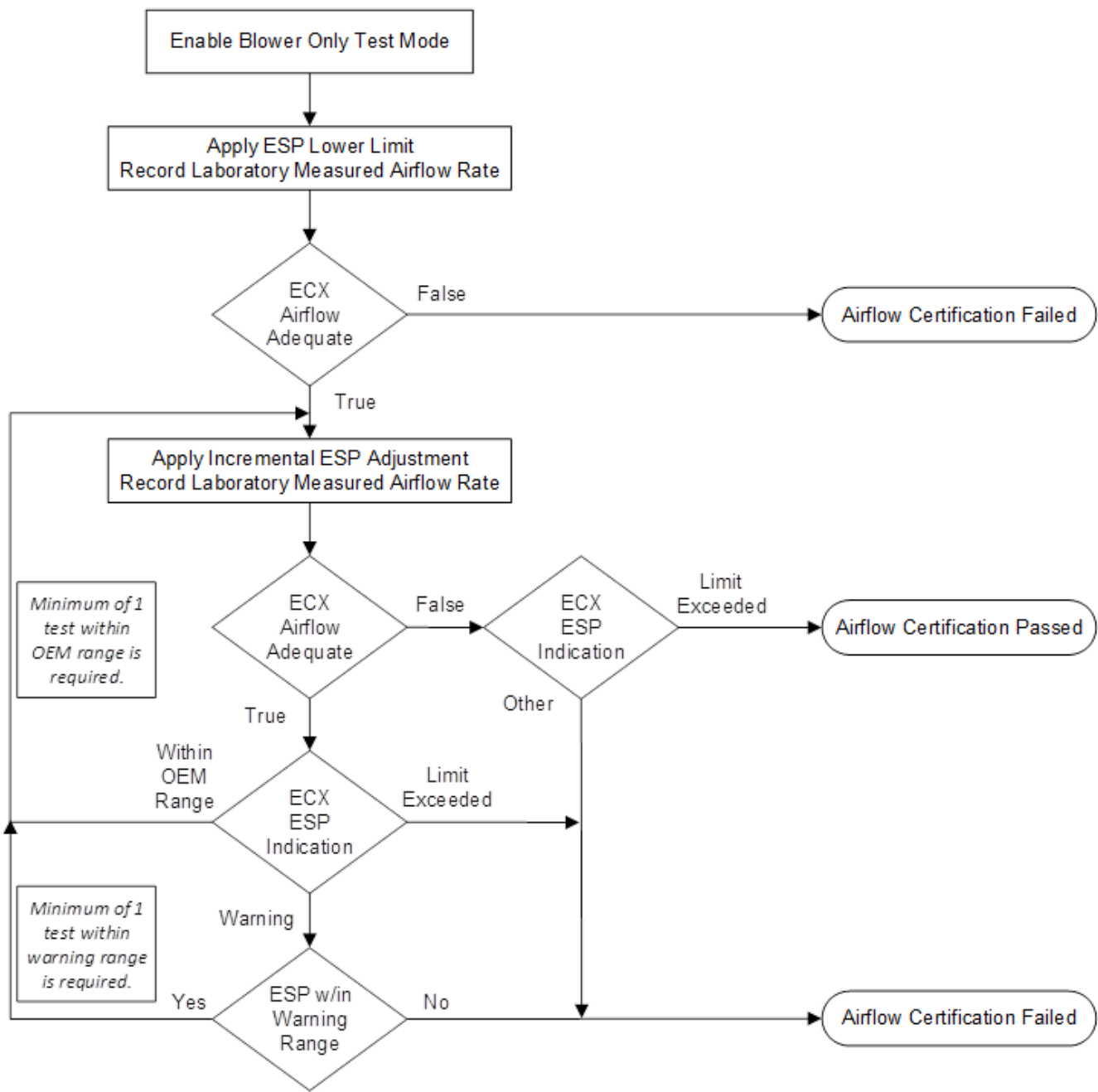
Figure 3. Charge Adequacy Certification Process Flowchart



5.4 Airflow Adequacy Certification Process Flowchart

Provided here for reference – see Embedded Commissioning certification document for accompanying details

Figure 4. Airflow Adequacy Certification Process Flowchart



5.5 Non-performance Criteria Review

The non-performance review is a review of reported values that do not require a True/False or Pass/Fail designation. All reported integer values must be measured and confirmed to be accurate to within $\pm 5\%$ of the reported values. Non-integer values must be verified to be reported as accurate.

5.6 Report Generation Review

The report generation review confirms all required values listed in Table 1 of section 2.2 are contained within the report generated by the Embedded Commissioning system and are acceptable to the allowed results in Table 1.

5.7 Commissioning Guidance Review

Evaluation of the commissioning tool and interface to provide feedback on how well it meets the eight (8) commissioning guidance elements outline in section 3. Reviewer to provide recommendations on where tool has room for improvement.

5.8 Qualified Product Listing (QPL)

NEEA will support and maintain the initial qualified product listing for utility program. Details of the process will be defined once the certification process has been completed.

The following is a conceptual outline of the process:

1. OEM completes verification certification process (third party reviewed)
2. OEM submits application with documentation and attestation of compliance
3. NEEA reviews application for compliance and a report generated from at least one field installation to confirm digital record generation works
4. NEEA maintains public list of product lines that meet specification
5. NEEA conducts independent verifications as needed

6. APPENDIX B: BACKGROUND OF EMBEDDED COMMISSIONING

6.1 Purpose of Embedded Commissioning

This specification provides guidance and alignment of manufacturers and market actors interested in developing residential heat pump products capable of conducting commissioning processes with enhanced measurement, reporting, and verification. The end goal of this effort is to ensure that the introduction of new generations of heat pump products will be installed to manufacturer specifications and any installation defects will be caught at time of commissioning, thus decreasing the energy and refrigerant wasted.

Utilities, states and other entities that invest in market transformation programs or incentives require reliable energy savings. Accordingly, this specification can improve confidence in savings and justification for investment by programs that accelerate market growth of Embedded Commissioning certified heat pumps.

5.2 Justification for Embedded Commissioning

Most VSHPs are installed by properly trained and diligent contractors and operate for years with no problems or loss of performance. A significant fraction, however, experience performance losses due to failure of the installer to properly commission the system for the situation in which it was installed¹.

Industry, government, and utilities have spent decades training, supporting, incentivizing, and studying how to ensure customers get the maximum benefit that high efficiency HVAC equipment can provide. During this time the technology of heat pumps and digital communications have improved substantially, making possible a new range of installer support through the use of low-cost sensors, wireless connectivity, and internet connected smartphones.

The energy savings opportunity can be attributed to two key areas: commission faults and choice of control settings which limit the operation of the heat pump. Table 1 and the subsequent equation provides an estimate of a fleet average energy savings potential of guided and verified commissioning of residential heat pumps. Assuming Embedded Commissioning capable equipment can address these issues, the likely improvement of in-field performance is likely ~4-5%, as not all issues identified by the Embedded Commissioning capable equipment, if used, will be addressed.

¹ <https://www.osti.gov/servlets/purl/1470985>

Table 2. Common System Faults and Estimated Savings Potential

Fault Name	Estimated Savings ^{2 3}	Likelihood of Error ⁴
Reduced Indoor Coil Airflow	5%	33%
Refrigerant Undercharge/ Overcharge	10%	28%
Refrigerant Subcooling	8%	Missing Data
Non-Condensable Gases	2%	Missing Data
Appropriate Aux heat control settings	8%	57%

$$\text{Commissioning Savings} = \sum_{\text{Fault}=i}^n \text{Savings}_i * \text{Likelihood}_i = 9\%$$

The benefits of quality commissioning of heat pumps are not limited to energy savings potential. Energy savings is not the only reason for this specification. Improved contractor practice, skill development of the installers, quality assurance, automatic extended warranty registration, customer engagement, and reduced call backs provide additional compelling reasons. Developing an industry specification which can differentiate products with onboard commissioning capabilities is one of the early steps to improving the value proposition for customers to purchase these systems and contractors to recommend them to their customers.

6.3 Embedded Commissioning Concept

When properly used, Embedded Commissioning capable equipment can accurately provide the following functions:

1. Real-time contractor guidance of installation and commissioning process
2. Certification report that verifies the system met requirements for proper commissioning
3. Documentation of system, settings, and conditions in which it was commissioned and registration of the equipment with the manufacturer

Embedded Commissioning is intended to provide just-in-time guidance for technicians and installers. This is more than just verifying what was done but also providing the installer with information that can help them make informed decisions and improve their standards of practice. This may include such things as:

- The appropriate crossover temperature
- Strip heat lockout

-
1. 2014 NIST fault impact [study](#)
 2. 2023 Ben Larson Research [memo](#)
 3. 2019 BPA's CC&S ASHP field [study](#)

- airflow settings to ensure adequate dehumidification
- when high duct static pressure will diminish performance
- over or undercharge of refrigerant

Several manufacturers (OEMs) are incorporating features that combine onboard sensors with internet-connected phone-based apps and cloud services onto their top-tier product lines with enhanced commissioning capabilities. Capabilities include requiring a minimal set of special tools, provide contractor guidance, and generate a validation report which is uploaded to the cloud for confirmation and future reference during service visits. To accelerate market adoption of these solutions we need to develop an Embedded Commissioning specification that defines the reporting requirements so a QPL can be generated. This document describes a proposed set of development activities which would accelerate and align the industry and energy efficiency efforts in the US and Canada to enable reliable and consistent embedded commissioning variable speed heat pumps.

Embedded Commissioning should not be confused with continuous automated fault detection and diagnostics (AFDD). Embedded Commissioning combines data collected by onboard sensors (and potentially third-party Bluetooth™ sensors) with the contractor's cellular connectivity to guide an HVAC installer, verify core operating parameters are within OEM specifications and benchmark initial conditions. The concept is to develop an validation test and certification for equipment capable of verifying and documenting that an Embedded Commissioning process was completed. The Embedded Commissioning report would verify core aspects needed to ensure energy efficiency. At a minimum this report would contain validation of refrigerant charge, indoor airflow, power draw, and control settings along with and identification of the installed equipment, time of installation, and location.

Embedded Commissioning does have some limitations. For example, it will not validate if the ductwork is properly sealed, the equipment is properly sized, or the choice of equipment is appropriate for the climate or application. These aspects of design and system verification would require additional information not gathered by onboard or connected third party sensors. Currently, these capabilities are beyond the scope of this project, which focuses on fault detection and diagnostics of parameters that can be detected when the system is first installed. Embedded Commissioning will not likely be successful unless the core Embedded Commissioning functions can be validated, and contractors find it reduces callbacks or equipment installation time.

The figure below provides a general illustration of components in an Embedded Commissioning capable solution. At a minimum it consists of a cellular connected device with a diagnostics app that collects data directly from tools and on-board sensors. The interface guides the contractor during the commissioning processes and evaluates core parameters of charge, indoor airflow, and control settings through direct or proxy measurements. The nature of how the commissioning validation is achieved would remain proprietary to the OEM, but the outputs of a commissioning report would be standardized with minimum criteria to ensure the heat pump is setup correctly.

The initial Embedded Commissioning specification needs to be simple enough for OEMs to achieve with minimal changes to the current products with onboard logic boards and some level of support provided through a customer cellular phone app. More advanced tiers that provide continuous AFDD or more precise or detailed commissioning services can be added over time.

We established seven core objectives to establish a clear Embedded Commissioning differentiation:

1. Build OEM alignment on definition and criteria (Embedded Commissioning Specification)
2. Develop a method of test to confirm if Embedded Commissioning solution meets the specification
3. Conduct field and lab validation of Embedded Commissioning method of test
4. Establish a QPL of Embedded Commissioning-capable products
5. Build market support for this differentiation in utility, state, and federal programs
6. Build contractor awareness and acceptance of using Embedded Commissioning
7. Build consumer interest in purchasing systems with Embedded Commissioning

6.4 Related Standards and Criteria

The following are several related standards and criteria. Some are required, others are included for reference and/or context.

6.4.1 Minimum Equipment Standards

The unit shall be approved by Underwriters Laboratories (UL), Electrical Testing Laboratories (ETL), CSA International (CSA), or an equivalent third-party agency to the applicable standards and have the ability to be installed in the U.S. and/or Canada. All systems should meet the following certification requirements to be considered compliant with this specification

Table 3. Related Standards and Criteria

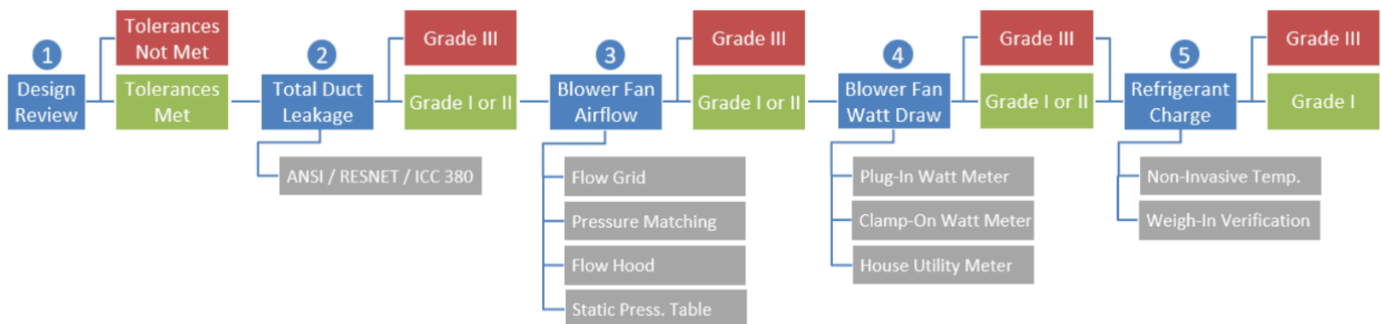
Applicable Standard or Criteria	Description
CFR 430.32(c)	Federal minimum efficiency standard for AC and heat pump systems
10 CFR part 430, Subpart B, Appendix M and M1	Federal Test Procedure for Unitary Small Equipment
10 CFR §429.16,	Federal regulation that dictates the certification, compliance, and testing requirements for central air conditioners and central air conditioning heat pumps

6.4.2 ANSI/RESNET/ACCA Standard 310-2020

ANSI/RESNET/ACCA standard 310⁵ establishes the procedures, tolerances, and record keeping practices for evaluating and grading elements of an HVAC System's design and installation. This standard is intended to support consistency in energy rating and labeling. It is intended for use by home energy raters, energy auditors, or HVAC contractors. It includes a design review and performance criteria for duct leakage, blower fan air flow and watt draw, refrigerant charge, and indirectly the system's control settings. The primary difference from this Embedded Commissioning specification is that it is contractor, or energy auditor, practice based rather than equipment capability based. An Embedded Commissioning system reduces the workload on an inspector or installer to provide 310 grading of a system but does not replace all the design documentation that it requires.

For purposes of this section, a thermostat or controller (for example, but not limited to devices such as smartphone or tablet with a manufacturer app to control the unit) can be considered part of the system. Items a, b, and c are understood to be measured at an appropriate fan speed and capacity.

Figure 5. Standard 310 Flowchart



6.4.3 EPA ENERGY STAR – Installation Capabilities

One of the desired outcomes of this specification is that Embedded Commissioning certified systems become an equivalent or replacement for the ENERGY STAR “Installation Capabilities” criteria. The following is an excerpt from the EPA criteria which requires systems to have three or two of the following capabilities for centrally ducted and non-ducted systems respectively.

- a) **Refrigerant charge:** System can self-verify that the refrigerant charge is within manufacturer recommended tolerances at a range of conditions including outdoor temperatures at least as low as 65°F or can estimate and report refrigerant charge

⁵ https://www.resnet.us/wp-content/uploads/ANSIRESNETACCA_310-2020_v7.1.pdf

level. An alert that only initiates when the charge is critically low does not satisfy this requirement.

- b) **Airflow measurement or external static pressure:** System shall have some capability to self- estimate and report airflow and/or confirm that it is within the OEM recommended settings, or to self-measure and display external static pressure and the fan speed setting. For split systems, this capability may be contingent on the recognized product being paired with a specific furnace or air handler. (Capability not applicable to ductless units.)
- c) **Blower fan power draw:** System shall have the capability to determine and report the watt draw of the blower fan. For split systems, this capability may be contingent on the recognized product being paired with a specific furnace or air handler. *Ductless systems exempt from blower fan power draw requirements.*
- d) **Test mode for manual measurements:** The system provides an easily accessible test mode that locks the system into an appropriate fan speed and compressor capacity setting for testing refrigerant charge, airflow/external static pressure, and blower fan power draw available in that installation.
- e) **Automatic system discovery:** System is capable of automatically recognizing compatible communicating indoor/outdoor units, furnaces. Automatic discovery of humidifiers and dehumidifiers is encouraged.
- f) **Preprogrammed system tests:** System shall automatically prompt the installer to run preconfigured system tests following the initial setup. These tests should verify, at a minimum, fan blower, cooling-mode, heat pump only heating, and auxiliary heating tests as applicable to the product and season of installation. The system shall store all faults recognized during these tests until the installer corrects the related issues.

7. APPENDIX C:

JSON FILE EXAMPLE

The following is an example JSON file Embedded Commissioning Report.

```
{
  "embedded_commissioning_report": {
    "serial_number": "XXXX-XXXXXXXXXX-XXXX",
    "met_embedded_commissioning_requirements": true,
    "date_of_commissioning": "2028-01-01",
    "location_of_installation": {
      "latitude": 40.7484,
      "longitude": -73.9857
    }
  },

  "system_information": {
    "manufacturer": "MrCool",
    "ahri_number": "XXXXXXXXXX",
    "indoor_unit_model": "XXXXXXXXXX",
    "outdoor_unit_model": "XXXXXXXXXX",
    "thermostat_make": "XXXXXXXXXX",
    "thermostat_model": "XXXXXXXXXX",
    "hspf2": 9.0,
    "seer2": 38.5,
    "eer2": 10.2,
    "cop_peak": 1.35
  },

  "conditions": {
    "suitable_for_commissioning": true,
    "outdoor_ambient_temperature": { "value": 75, "unit": "Fahrenheit" },
    "avg_indoor_temperature_during_test": { "value": 72, "unit": "Fahrenheit" }
  },

  "refrigerant": {
    "charge_adequacy": true,
    "liquid_line_temperature": { "value": 80, "unit": "Fahrenheit" },
    "degrees_of_subcooling": { "value": 10, "unit": "Fahrenheit" },
    "target_subcooling": { "value": 10, "unit": "Fahrenheit" }
  },

  "airflow": {
```

```

"adequacy": true,
"fan_power": { "value": 300, "unit": "Watts" },
"airflow": { "value": 800, "unit": "CFM" },
"fan_efficiency": { "value": 0.58, "unit": "Watt/CFM" }
},

"controls": {
  "auxiliary_heat_lockout": {
    "setting": "Auxiliary Heat Lockout Temp",
    "temperature": { "value": 35, "unit": "Fahrenheit" }
  },
  "compressor_lockout": {
    "setting": "Compressor Lockout Temp",
    "temperature": { "value": 17, "unit": "Fahrenheit" }
  },
  "setback_recovery_mode": "Off",
  "wifi_connectivity": "Connected",
  "load_flex_capability": "AHRI 1380",
  "switchover": {
    "setting": "Switchover Temp",
    "temperature": { "value": 30, "unit": "Fahrenheit" }
  }
}
}
}

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