AIR-TO-AIR HEAT PUMPS  INSTALLATION CERTIFICATION

Certification Information
Scope - Tests a candidate’s knowledge of the installation, service, maintenance, and repair of HVAC systems. System sizes are limited to 30 tons or less cooling capacity.

Qualifications

✓ This is a test and certification for TECHNICIANS in the HVAC industry. The test is designed for top level installation technicians. This test for certification is not intended for the HVAC system designer, sales force, or the engineering community. To become NATE-certified, you must pass this specialty and a CORE INSTALL exam.

✓ This test will measure what 80% of the Heat Pumps candidates have an 80% likelihood of encountering at least once during the year on a NATIONAL basis.

✓ Suggested requirement is one year of field experience working on Heat Pumps systems as an installation technician and technical training for theoretical knowledge.

Test Specifications

<table>
<thead>
<tr>
<th>Closed Book</th>
<th>2.5 Hour Time Limit</th>
<th>100 Questions</th>
<th>Passing Score: PASS/FAIL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Listed are the percentages of questions that will be in each section of the Heat Pumps exam.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SECTION AREA DESCRIPTION</th>
<th>SECTION PERCENTAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Installation</td>
<td>43%</td>
</tr>
<tr>
<td>Service</td>
<td>10%</td>
</tr>
<tr>
<td>System Components</td>
<td>27%</td>
</tr>
<tr>
<td>Applied Knowledge</td>
<td>20%</td>
</tr>
</tbody>
</table>

Heat Pumps Industry References

The reference materials listed below will be helpful in preparing for this exam. These materials may NOT contain all of the information necessary to be competent in this specialty or to pass the exam.

- American National Standards Institute (ANSI) / Air Conditioning Contractors of America (ACCA) Manuals - Latest Edition
  - “D”, “J”, “QI” - Quality Installation, and “S”
- ACCA Manuals “T” and “RS” - Latest Editions
- ACCA Residential Duct Diagnostics and Repair - Latest Edition
- AHRI-Hyrdronics Section-IBO/RAH Latest Edition
- International Mechanical Code - Latest Edition with Addendum
- International Plumbing Code - Latest Edition with Addendum
- Uniform Mechanical Code - Latest Edition with Addendum
- ENERGY STAR™ Home Sealing Standards - Latest Edition with Addendum
- Duct Calculators – Sheet Metal, Ductboard, and Flexible Duct
- American National Standards Institute (ANSI) / Sheet Metal and Air Conditioning Contractors’ National Association, Inc. (SMACNA) Manuals
  - HVAC Duct Construction Standards - Metal and Flexible
  - Sheet Metal and Air Conditioning Contractors’ National Association, Inc. (SMACNA) Manuals
- Air Diffusion Council Flexible Duct Performance & Installation Standards
- North American Insulation Manufacturers Association (NAIMA) Manuals
  - Fiberglass Glass Duct Construction Standards and A Guide to Insulated Air Duct Systems

Passing Score Development Process

The passing scores for the NATE tests were established using a systematic procedure (a Passing Score Study). This procedure employed the judgment of experienced HVAC professionals and educators representing various HVAC specialties and geographical areas. The passing scores were set using criteria defining competent performance. The passing score for different test forms may vary slightly due to the comparative difficulty of the test questions.

Exam Copyrights

All testing documents and questions are the copyrighted property of North American Technician Excellence Inc.-NATE. It is forbidden under federal copyright law to copy, reproduce, record, distribute or display these documents or questions by any means, in whole or part, without written permission from NATE. Doing so may subject you to severe civil and/or criminal penalties, including imprisonment and/or fines for criminal violations.
Heating - Reverse Cycle Air to Air
Installer

INSTALLATION

FABRICATING COPPER TUBING

REFRIGERANT LINE INSTALLATION
Locating, mounting, and routing
Understanding limitations of length and diameter

BENDING COPPER TUBING
Making a proper bend with spring benders
Making a proper bend with cam type benders

COPPER TUBING PREPARATION
Cutting copper tubing
Reaming copper tubing
Cleaning copper tubing
Swaging copper tubing

BRAZING
Overview of brazing copper to copper
Oxyacetylene brazing
Using air / fuel to solder
Use of purging gas when brazing
Overview of brazing copper to brass
Overview of brazing copper to steel
Selection of brazing materials

FLARE FITTINGS
Making a flare fitting - single and double
Installing with flare fittings

BRAZING & SOLDERING EQUIPMENT
Brazing products - rods, flux, etc.
Oxyacetylene brazing equipment
Gas purging equipment in field brazing
Air / Fuel systems - acetylene, propane, MAP, etc.
Soldering products - solder, flux, and torches
Tool maintenance and care

INSTALLING OUTDOOR UNITS
INSTALLING AND CONNECTING OUTDOOR UNITS
Locating unit
Preparing site
Placing unit
Wiring outdoor units
Connecting refrigerant lines

INSTALLING PACKAGED UNITS
INSTALLING AND CONNECTING PACKAGED UNITS
Locating equipment
Preparing site
Lifting unit
Sealing unit
Wiring

INSTALLING INDOOR EQUIPMENT
INSTALLATION OF INDOOR AIR HANDLERS / FURNACES
Installing coil and air handler / furnace
Connecting ductwork
Connecting refrigerant lines
Connecting condensate lines
Wiring air handler / furnace
Wiring thermostats
Wiring electronic air cleaners
TEV's - installation
Installing fixed metering devices
Bulb location selection for TEV's
Evacuation & Charging

Safe Handling of Refrigerant Containers
- Disposal
- Securing refrigerants for transport
- Signage and documentation for refrigerants
- Proper storage
- Proper container filling

Evacuation
- Overview - use of a vacuum pump
- Overview - use of a micron gauge
- Use of a manifold gauge set in evacuation
- Deep single evacuation process
- Removing core of access valves

Leak Checking & Detection
- Overview of leak checking and detection
- Leak checking with electronic leak detectors
- Leak checking with soap solutions
- Gas pressurization for leak checking
- Leak checking with ultrasonic leak detectors

Charging Method
- Weigh in method
- Superheat method and where used
- Subcooling method and where used
- Charging blended refrigerants

Duct Installation

Duct Fabrication Equipment
- Ductboard tools - 90 V-groove, end cutoff, female shiplap, hole cutter, stapler, etc.
- Flex tools - tensioning strap tools, knives, etc.
- Metal tools - metal snips, sheers, benders, breaks, hand formers, calipers, rulers, stapler, etc.

Installing Metal Duct
- Assembly methods for rectangular duct
- Assembly methods for round duct
- Hanging ductwork
- Sealing metal duct
- Insulation - internal and external

Installing Flexible Duct
- Assembly methods - appropriate length
- Hanging flexible duct
- Sealing flexible duct
- Installation Technique

Installing Ductboard
- Assembly methods for ductboard - supports
- Hanging methods for ductboard
- Sealing ductboard
- Installation Technique

Installing Grilles, Registers, Diffusers, & Damper
- Mounting to ductwork
- Securing methods
- Sealing methods

Field Construction / Installation
- Techniques for joining dissimilar duct
- Duct of alternate materials - wood, aluminum, etc.

Chases Used as Ducts
- Floor joists as air ducts
- Vertical chases

Installing Accessories

Installing Thermostats
Locating and mounting
Wiring electromechanical thermostats
Wiring electronic thermostats
Setting anticipators when used
Installing air side low ambient control
Installing outdoor thermostat
Setting balance point on outdoor thermostat

INSTALLED AIR CLEANERS
Installing to a unit - sealing
Wiring
Controlling electronic air cleaners

INSTALLING HUMIDIFIERS
Installing
Wiring
Controlling humidifiers

INSTALLING ECONOMIZERS
Installing
Wiring
Controlling economizers

FIELD WIRING
WIRING UNITS & CONTROL WIRING
Connecting electrical power
Connecting control circuits
Meeting manufacturer sizing requirements - wire sizing (size and number)

START-UP AND CHECKOUT
PRE-START PROCEDURES
Surveying installation - checking equipment match
Inspect connections for tightness
Set dip switches/jumpers on CEM motors
Set speed taps on multi-speed motors
Set adjustable pulleys on belt driven blowers
Ensure clean filter is in place and accessible
Ensure condensate line is flowing

START-UP PROCEDURES AND CHECKS
Surveying installation
Supply voltage checks
Motor checks
Checking sequences
Check fan rotation
Check scroll compressor rotation - high noise level, etc. Start-up checklist and preparation
Metering device - refrigerant circuit checks
Airflow checks
Pressure checks
Temperature checks - dry bulb, wet bulb, etc.
Reversing valve checks

LEAK DETECTION TOOLS
Soap solution
Electronic leak detectors
Ultrasonic leak detector
Halide leak detector
Use of dye leak detectors

REFRIGERANT CIRCUIT TOOLS
MANIFOLD GAUGE SET
Manifold gauge set
How to read the gauge set
How to connect the gauge set for different purposes
Types and styles of gauge sets
Using the gauge set for diagnostics
Low loss fitting connections
Gauge calibration and maintenance

**EVACUATION TOOLS**
- Vacuum pump
- Micron gauge
- Valve opening tools - core removers, etc.
- Gauge calibration and maintenance

**CHARGING TOOLS**
- Charging scales

**DUCT FABRICATION**

**FABRICATION TECHNIQUES FOR METAL DUCT**
- Seam types - pittsburgh and snap lock
- Joint Types - drive slips, reinforced drive slips, "s" slip, and standing "s" slip
- Use of strength breaks in rectangular duct

**FABRICATION TECHNIQUES FOR DUCTBOARD**
- Layout of duct fitting
- Groove cutting - hand / machine
- Use of joint tape

**RETROFITTING**

**EQUIPMENT COMPONENT RETROFITTING**
- Changing out an outdoor unit
- Changing out an indoor unit
- Modifying ductwork for replacement equipment

**AIRFLOW MEASUREMENTS**

**INTRODUCTION TO AIRFLOW MEASUREMENTS**
- Introduction to airflow
- Static pressure

**AIRFLOW VELOCITY MEASUREMENTS**
- Introduction to airflow velocity
- Velometer - electronic and mechanical
- Anemometer
- Velocity measurement procedures
- Gauge calibration

**AIRFLOW PRESSURE MEASUREMENTS**
- Overview of static pressure measurements
- Inclined manometer
- Diaphragm type differential pressure gauge
- U-tube manometer
- Electronic manometer / pressure measurement
- Gauge / meter calibration
- Absolute vs. Gauge Pressure

**AIRFLOW VOLUME MEASUREMENTS**
- Introduction to volume
- Airflow hood
- Formulae for determining CFM of air
- Formulae for weight of air
- Locations for air volume measurements

**AIRFLOW CHECKS & DESIGN TOOLS**
- Using manufacturer's airflow charts and tables
- Using a duct calculator and design charts

**SERVICE**

**DIAGNOSTICS**

**PRELIMINARY SYSTEM DIAGNOSTICS**
- Outdoor unit checks
- Indoor unit checks
- Wiring checks
- Refrigerant line checks
- Thermostat checks
- Condensate drain checks
- Accessories

**ELECTRICAL CHECKS**
Supply checks
Compressor circuits
Condenser fan circuits
Indoor blower circuits
Thermostat circuits
Transformer circuits
Defrost control circuits
Indoor auxiliary heat circuits
Reversing valve solenoid circuits
Electronic controllers - input / output

ELECTRICAL COMPONENT CHECKS
Thermostat
Transformers
Overcurrent protection
Relays and contactors
Condenser fans
Indoor blowers
Solenoid valves coils
Defrost termination control
Outdoor thermostats

REPAIR
Refrigerant circuit on coils
Ductwork
Electrical wiring

INTRODUCTION TO ELECTRICAL TROUBLESHOOTING

LOW VOLTAGE CIRCUITS
Voltage tests
Equipment continuity tests
Ground tests

LINE VOLTAGE CIRCUITS
Voltage tests
Equipment continuity tests
Ground tests

SYSTEM COMPONENTS

INTRODUCTION TO SYSTEMS

HEAT TRANSFER PRINCIPLES
Heat transfer - evaporation and condensation
Basic refrigeration circuit - 10 components
Temperature and pressure in the refrigerant circuit

SPLIT SYSTEMS
Introduction to split system heat pump configurations and applications
Equipment locations and mounting
Duct designs for split systems heat pumps
Electrical layouts for split systems heat pumps
Refrigerant circuits for split systems heat pumps
Specifications for split system heat pumps
Attic / crawlspace layouts for split systems heat pumps
Closet layouts for split systems heat pumps
Basement layouts for split systems heat pumps
Auxiliary heat options with split system heat pumps
Ventilation options heat pumps
Regional considerations in split system heat pump designs
Special consideration of indoor coils above living space

PACKAGED SYSTEMS
Introduction to package heat pump configurations
Equipment locations for package heat pumps
Basic duct designs for packaged equipment
Electrical layouts with packaged heat pumps
Packaged equipment in single story applications
Packaged equipment in multi story applications
Packaged equipment in crawlspace applications
Heat options with packaged heat pumps
Ventilation options for packaged heat pumps
Economizer options
Regional considerations in packaged equipment
Specifications for packaged equipment

MULTI-CAPACITY SYSTEMS
Overview of multi-capacity systems
Sequencing of multi-capacity heat pumps
Refrigerant circuits
Indoor Airflow
  MDU of need to adjust airflow per capacity requirements
MDU of need to adjust airflow per capacity requirements

THE BASIC HEAT PUMP REFRIGERANT CIRCUIT
Basic circuit layout for a heat pump
Role of compressor
Role of evaporator
Role of condenser
Role of metering device
Role of high pressure vapor line
Role of low pressure suction line
Role of reversing valves

THE HEAT PUMP REFRIGERATION CYCLE OPERATING MODES
Heat pump circuit operation in the cooling mode
Heat pump circuit operation in the heating mode
The defrost cycle

DUCT SYSTEMS
Duct system materials - metal, ductboard, flexible duct, PVC, etc.
Duct configurations - extended plenum, reducing extended plenum, perimeter radial, perimeter loop, overhead radial
Return configurations - ducted, central, etc.
Return grille locations - low sidewall, high sidewall, etc.
Supply locations - floor, sidewall, ceiling, etc.
Duct locations - attic, basement, crawlspace, slab, roof, furr down, and exposed
Fitting nomenclature - plenum, transition, elbow, round duct, rectangular duct, turning vanes, wyes, and sheet metal duct joints

WIRING LAYOUTS
POWER WIRING
  Overview of power wiring
  Single phase wiring
  Three-phase wiring

LOW VOLTAGE
  Overview of low voltage wiring

COMPONENTS
OUTDOOR COILS
  Types - basic designs
  Airflow characteristics

COMPRESSORS
  Fundamentals of compressor operations
  Compressor types
  Introduction to start components
  Selecting start components
  Considerations in using start components
  Hard start kits - potential relay and start capacitor
  Soft start PTCR assists

REFRIGERANTS
  Refrigerants used in Res./Lt. Com heat pumps
  Properties of refrigerants used in Res./Lt. Com heat pumps
  Using temperature-pressure chart
Refrigerant conservation

SERVICE VALVES
- Front seating service valves
- Back seating service valves
- Gauge port

REFRIGERANT CIRCUIT ACCESSORIES
- Operation fundamentals - accumulators
- Operation fundamentals - filter-driers, bi-directional
- Operation fundamentals - sight glasses, moisture indicators, liquid indicators, etc.
- Muffers

INDOOR COILS
- Types - basic designs and operating characteristics of A-coil, slab, and slant indoor coils
- Basics of selection
- Condensate drains

METERING DEVICES
- Types
- Selection

BLOWERS AND FANS
- Role of indoor blowers
- Role of outdoor fans

LINE SETS
- Introduction to line sets
- Application considerations when using line sets

AIR SIDE COMPONENTS
- Dampers
- Ventilation fittings
- Electronic air cleaners (EAC's)
- Electrostatic filters - non-electric
- Media type filters
- Fixed outdoor air damper
- Insulating material
- Flexible connectors

GRILLES, REGISTERS, & DIFFUSERS
- Types and uses

FASTENERS
- Screws
- Bolts
- Nuts and washers
- Lockpins
- Rivets

ELECTRICAL COMPONENTS
- Overcurrent protection
- Capacitors
- Solenoids
- Crankcase heaters
- Auxiliary heat
- Transformers

REVERSING VALVES
- Basics of operation
- Components

CONSTANT AIRFLOW MOTORS
- Intro to variable speed motors - ECM, BPM, and VSIM
- Motor mounting and installation requirements
- Electronic interface and setting for airflow requirements

ELECTROMECHANICAL SENSING CONTROLS

ELECTROMECHANICAL WALL THERMOSTATS
- Basic thermostat types and operation
- Thermostat terminals and wiring
- Using electromechanical thermostats

ELECTROMECHANICAL TEMPERATURE CONTROLS
Introduction to bimetal controls
Disc type temperature limit controls
Introduction to vapor charged controls
Overview of electric heat high limits
Motor overloads
PRESSURE CONTROLS
Introduction to disc type pressure controls and hi/low controls
Operation of disc type pressure controls
ELECTROMECHANICAL OUTDOOR THERMOSTATS
Overview of outdoor thermostats
Outdoor thermostat wiring
Low ambient cooling controls
REFRIGERANT CIRCUIT CONTROLS
PRESSURE CONTROLS
High pressure limit controls
Low pressure limit controls
NON-SENSING CONTROLS
RELAYS AND CONTACTORS
Introduction to relays and contactors
Basics of relay and contactor operation - inrush and holding
Selecting relays and contactors
Application considerations for relays and contactors
ELECTRIC HEAT CONTROLS
Sequencers
ELECTRONIC CONTROLS
ELECTRONIC THERMOSTATS
Fundamentals of electronic thermostats
Overview of electronic thermostat operation
ZONE CONTROLS
Fundamentals of zone controls
Typical zone control logic
ELECTRONIC COMPRESSOR CONTROLS
Fundamentals of compressor controls
Operation of compressor controls
ELECTRONIC TIMERS
Introduction to blower delay timers
Introduction to compressor delay timers
ELECTRONIC DEFROST CONTROLLERS
Fundamentals of electronic defrost controllers
APPLICATION KNOWLEDGE: REGS, CODES, & DESIGN
AIR QUALITY REGULATIONS
INDOOR AIR QUALITY
Fresh air supplies
ELECTRICAL CODE
Requirements
Overview of electrical code
Circuit breaker and fuse requirements
General wiring practices
Class I wire sizing
Class II wire sizing
Conduit sizing
Definitions
STATE AND LOCAL REGULATIONS AND CODES
STATE AND LOCAL REGULATIONS
State requirements for technicians
CODES
Plumbing
Municipalities
HVAC for Lt. Commercial
FIRE PROTECTION REGULATIONS AND CODES

REQUIRED COMPONENTS
- Return air sensors
- Fire dampers

FIRE PREVENTION
- Overview

DESIGN CONSIDERATIONS - COMFORT

TEMPERATURE
- Designing for capacity

HUMIDITY
- Role of humidity in comfort

INDOOR AIR QUALITY
- Ventilation - comfort
- Air cleaning for comfort
- Outside air

SOUND LEVEL
- Equipment location considerations
- Isolation, mounting pad, duct, and structure
- Duct systems

DESIGN CONSIDERATIONS - EQUIPMENT

SPLIT SYSTEMS
- System designs - closets, basements, etc.
- Refrigerant piping
- Equipment location
- Electrical layouts
- Duct design / balancing
- Condensate drains
- Ventilation - fresh air
- Regional design considerations
- Ventilation - equipment
- Secondary condensate drains / pans
- Mounting of equipment
- Auxiliary heat options

PACKAGED SYSTEMS
- Package system configurations and design
- Equipment locations design
- Applications for packaged systems
- Basic duct designs for packaged equipment
- Condensate drain piping design
- Electrical layouts with packaged heat pumps
- Packaged equipment in single story applications
- Packaged equipment in multi story applications
- Packaged equipment in crawl space applications
- Heat options with packaged systems
- Ventilation options
- Regional considerations in packaged equipment

DESIGN CONSIDERATIONS - COMPONENTS

DIFFUSERS, REGISTERS, AND GRILLES
- Selecting diffusers, grilles, and registers
- Modifying locations

ACCESSORIES
- Start components
- Filter-driers - When to use? and How to select?
- Filtration - EAC, media, HEPA, electrostatic
- Outdoor thermostats - lockout auxiliary heat
- Wall thermostat options - electric heat stat vs gas heat stat

MECHANICAL CODE

EQUIPMENT ACCESS
- Minimum clearance
- Electrical disconnects
Fire dampers

**REFRIGERANT LINE ROUTING**
- Support requirements
- Inspection requirements

**CONDENSATE DRAINS**
- Materials
- Sizing

**RECOVERY / RECYCLING MACHINES**

**RECOVERY MACHINES**
- Introduction to recovery machines
- Types and styles of recovery machines
- Typical recovery procedures
- Recovery machine maintenance and cylinder maintenance

**RECYCLING MACHINES**
- Introduction to recycling machines
- Types and styles of recycling machines
- Typical recycling procedures
- Recovery machine maintenance and cylinder maintenance
\[
\frac{\text{CFM}_n}{\text{CFM}_o} = \frac{\text{RPM}_n}{\text{RPM}_o} \quad o = \text{old}, n = \text{new} \\
\text{CFM and RPM are interchangeable.}
\]

\[
\left(\frac{\text{CFM}_n}{\text{CFM}_o}\right)^2 = \frac{\text{Sp}_n}{\text{Sp}_o} \quad \text{OR} \quad \text{CFM}_n = \text{CFM}_o \times \frac{\text{Sp}_n}{\text{Sp}_o},
\]

\[
\left(\frac{\text{CFM}_o}{\text{CFM}_o}\right)^3 = \frac{\text{BHP}_n}{\text{BHP}_o} \quad \text{OR} \quad \text{CFM}_o = \frac{\text{BHP}_n}{\text{BHP}_o}
\]

\[
\text{Hydronics:} \quad AP = \text{Sp}, \quad \text{CFM} = \text{GPM}, \quad \text{RPM} = \text{GPM}
\]

\[
\text{MAT} = (\text{OAT} \times \%0A) + (\text{RAT} \times \%RA)
\]

\[
0 = \text{Outside} \quad T = \text{Temperature} \quad R = \text{Return} \quad M = \text{Mixed} \quad A = \text{Air}
\]

\[
\text{AC/Hr} \times \text{Volume} \quad \text{CFM} = \frac{\text{v}}{60\text{min}}
\]

\[
V = 4005 \times .Jvp \quad \text{Vp} = <4:05 \text{J}>
\]

\[
\text{Pressure (PSI)} = 0.433 \times \text{Head (feet of water)}
\]

\[
1 \text{IWC} = 0.0360 \text{PSI} \quad 1 \text{PSI} = 27.72 \text{IWC}
\]

\[
\text{Pressure 1} \times \text{Volume 1} = \text{Pressure 2} \times \text{Volume 2}
\]

\[
\text{Area} = \text{1t} \times \text{radius}^2
\]

\[
A^2 + B^2 = C
\]

\[
\text{Diameter} = \frac{\text{Circumference}}{\text{1t}}
\]

\[
\text{ASP} \times 100
\]

\[
\text{FR} = \text{TEL} \quad (\text{IWq}100)
\]

\[
\text{CFM} = \text{Velocity (fpm)} \times \text{Duct Area (ft}^2\text{)}
\]

\[
\text{CFM} = (\text{Watts} \times 3.413) \quad \{\text{AT} \times 1.08\}
\]

\[
\text{Cr (Series)} = \frac{1}{\frac{1}{C_1} + \frac{1}{C_2} + ... + \frac{1}{C_n}}
\]

\[
\text{C_r (Parallel)} = C_1 + C_2 + ... + C_n
\]
To determine subcooling for 404A, 407C, and 4220, use BUBBLE POINT values (temperatures above 50°F - gray background).

To determine superheat for 404A, 407C, and 4220, use DEW POINT values (temperatures 50°F and below).

<table>
<thead>
<tr>
<th>TEMP.</th>
<th>REFRIGERANT</th>
</tr>
</thead>
<tbody>
<tr>
<td>OCC</td>
<td>22</td>
</tr>
<tr>
<td>40.0</td>
<td>0.6</td>
</tr>
<tr>
<td>-36</td>
<td>3.4</td>
</tr>
<tr>
<td>-32</td>
<td>5.9</td>
</tr>
<tr>
<td>-28</td>
<td>8.7</td>
</tr>
<tr>
<td>-24</td>
<td>10.8</td>
</tr>
<tr>
<td>-20</td>
<td>12.5</td>
</tr>
<tr>
<td>-16</td>
<td>14.6</td>
</tr>
<tr>
<td>-12</td>
<td>16.5</td>
</tr>
<tr>
<td>-8</td>
<td>18.9</td>
</tr>
<tr>
<td>-4</td>
<td>21.3</td>
</tr>
<tr>
<td>0</td>
<td>24.0</td>
</tr>
<tr>
<td>1</td>
<td>24.9</td>
</tr>
<tr>
<td>2</td>
<td>25.7</td>
</tr>
<tr>
<td>3</td>
<td>26.5</td>
</tr>
<tr>
<td>4</td>
<td>27.4</td>
</tr>
<tr>
<td>5</td>
<td>28.3</td>
</tr>
<tr>
<td>6</td>
<td>29.2</td>
</tr>
<tr>
<td>7</td>
<td>30.1</td>
</tr>
<tr>
<td>8</td>
<td>30.7</td>
</tr>
<tr>
<td>9</td>
<td>31.3</td>
</tr>
<tr>
<td>10</td>
<td>31.6</td>
</tr>
<tr>
<td>11</td>
<td>31.9</td>
</tr>
<tr>
<td>12</td>
<td>32.2</td>
</tr>
<tr>
<td>13</td>
<td>32.5</td>
</tr>
<tr>
<td>14</td>
<td>32.7</td>
</tr>
<tr>
<td>15</td>
<td>32.9</td>
</tr>
<tr>
<td>16</td>
<td>33.1</td>
</tr>
<tr>
<td>17</td>
<td>33.3</td>
</tr>
<tr>
<td>18</td>
<td>33.5</td>
</tr>
<tr>
<td>19</td>
<td>33.7</td>
</tr>
<tr>
<td>20</td>
<td>33.8</td>
</tr>
<tr>
<td>21</td>
<td>33.9</td>
</tr>
<tr>
<td>22</td>
<td>34.0</td>
</tr>
<tr>
<td>23</td>
<td>34.1</td>
</tr>
<tr>
<td>24</td>
<td>34.2</td>
</tr>
<tr>
<td>25</td>
<td>34.3</td>
</tr>
<tr>
<td>26</td>
<td>34.4</td>
</tr>
<tr>
<td>27</td>
<td>34.5</td>
</tr>
<tr>
<td>28</td>
<td>34.6</td>
</tr>
<tr>
<td>29</td>
<td>34.7</td>
</tr>
<tr>
<td>30</td>
<td>34.8</td>
</tr>
<tr>
<td>31</td>
<td>34.9</td>
</tr>
</tbody>
</table>

CONTINUED
<table>
<thead>
<tr>
<th>TEMP.</th>
<th>0°C</th>
<th>22°C</th>
<th>404A</th>
<th>407C</th>
<th>410A</th>
<th>4220</th>
<th>507</th>
</tr>
</thead>
<tbody>
<tr>
<td>32</td>
<td>0.0</td>
<td>57.5</td>
<td>27.8</td>
<td>72.4</td>
<td>52.1</td>
<td>101.2</td>
<td>55.2</td>
</tr>
<tr>
<td>33</td>
<td>0.6</td>
<td>58.8</td>
<td>28.6</td>
<td>73.9</td>
<td>53.4</td>
<td>103.3</td>
<td>56.5</td>
</tr>
<tr>
<td>34</td>
<td>1.1</td>
<td>60.2</td>
<td>29.5</td>
<td>75.5</td>
<td>54.8</td>
<td>105.4</td>
<td>57.9</td>
</tr>
<tr>
<td>35</td>
<td>1.7</td>
<td>61.5</td>
<td>30.4</td>
<td>77.1</td>
<td>56.1</td>
<td>107.5</td>
<td>59.3</td>
</tr>
<tr>
<td>36</td>
<td>2.2</td>
<td>62.9</td>
<td>31.3</td>
<td>78.7</td>
<td>57.5</td>
<td>109.7</td>
<td>60.6</td>
</tr>
<tr>
<td>37</td>
<td>2.8</td>
<td>64.3</td>
<td>32.2</td>
<td>80.3</td>
<td>58.9</td>
<td>111.9</td>
<td>62.0</td>
</tr>
<tr>
<td>38</td>
<td>3.3</td>
<td>65.7</td>
<td>33.1</td>
<td>82.0</td>
<td>60.3</td>
<td>114.1</td>
<td>63.5</td>
</tr>
<tr>
<td>39</td>
<td>3.9</td>
<td>67.1</td>
<td>34.1</td>
<td>83.7</td>
<td>61.7</td>
<td>116.3</td>
<td>64.9</td>
</tr>
<tr>
<td>40</td>
<td>4.4</td>
<td>68.6</td>
<td>35.0</td>
<td>85.4</td>
<td>63.2</td>
<td>118.6</td>
<td>66.4</td>
</tr>
<tr>
<td>42</td>
<td>5.6</td>
<td>71.5</td>
<td>37.0</td>
<td>88.8</td>
<td>66.1</td>
<td>123.2</td>
<td>69.4</td>
</tr>
<tr>
<td>44</td>
<td>6.7</td>
<td>74.5</td>
<td>39.0</td>
<td>92.4</td>
<td>69.2</td>
<td>127.9</td>
<td>72.5</td>
</tr>
<tr>
<td>46</td>
<td>7.8</td>
<td>77.6</td>
<td>41.1</td>
<td>96.0</td>
<td>72.3</td>
<td>132.8</td>
<td>75.6</td>
</tr>
<tr>
<td>48</td>
<td>8.9</td>
<td>80.8</td>
<td>43.2</td>
<td>99.8</td>
<td>75.5</td>
<td>137.8</td>
<td>78.9</td>
</tr>
<tr>
<td>50</td>
<td>10.0</td>
<td>84.1</td>
<td>45.4</td>
<td>103.6</td>
<td>78.8</td>
<td>142.9</td>
<td>82.2</td>
</tr>
<tr>
<td>52</td>
<td>11.1</td>
<td>87.4</td>
<td>47.7</td>
<td>109.2</td>
<td>101.7</td>
<td>148.1</td>
<td>96.1</td>
</tr>
<tr>
<td>54</td>
<td>12.2</td>
<td>90.8</td>
<td>50.0</td>
<td>113.3</td>
<td>105.6</td>
<td>153.5</td>
<td>99.8</td>
</tr>
<tr>
<td>56</td>
<td>13.3</td>
<td>94.4</td>
<td>52.4</td>
<td>117.4</td>
<td>109.6</td>
<td>159.0</td>
<td>103.6</td>
</tr>
<tr>
<td>58</td>
<td>14.4</td>
<td>98.0</td>
<td>54.9</td>
<td>121.7</td>
<td>113.7</td>
<td>164.7</td>
<td>107.4</td>
</tr>
<tr>
<td>60</td>
<td>15.6</td>
<td>101.6</td>
<td>57.4</td>
<td>126.0</td>
<td>117.9</td>
<td>170.4</td>
<td>111.4</td>
</tr>
<tr>
<td>62</td>
<td>16.7</td>
<td>105.4</td>
<td>60.0</td>
<td>130.5</td>
<td>122.3</td>
<td>176.3</td>
<td>115.4</td>
</tr>
<tr>
<td>64</td>
<td>17.8</td>
<td>109.3</td>
<td>62.7</td>
<td>135.0</td>
<td>126.7</td>
<td>182.4</td>
<td>119.5</td>
</tr>
<tr>
<td>66</td>
<td>18.9</td>
<td>113.2</td>
<td>65.4</td>
<td>139.7</td>
<td>131.2</td>
<td>188.6</td>
<td>123.8</td>
</tr>
<tr>
<td>68</td>
<td>20.0</td>
<td>117.3</td>
<td>68.2</td>
<td>144.4</td>
<td>135.8</td>
<td>194.9</td>
<td>128.1</td>
</tr>
<tr>
<td>70</td>
<td>21.1</td>
<td>121.4</td>
<td>71.1</td>
<td>149.3</td>
<td>140.5</td>
<td>201.4</td>
<td>132.5</td>
</tr>
<tr>
<td>72</td>
<td>22.2</td>
<td>125.7</td>
<td>74.1</td>
<td>154.3</td>
<td>145.4</td>
<td>208.0</td>
<td>137.1</td>
</tr>
<tr>
<td>74</td>
<td>23.3</td>
<td>130.0</td>
<td>77.1</td>
<td>1594</td>
<td>150.3</td>
<td>214.8</td>
<td>141.7</td>
</tr>
<tr>
<td>76</td>
<td>24.4</td>
<td>134.5</td>
<td>80.2</td>
<td>164.6</td>
<td>155.4</td>
<td>221.8</td>
<td>146.5</td>
</tr>
<tr>
<td>78</td>
<td>25.6</td>
<td>139.0</td>
<td>83.4</td>
<td>169.9</td>
<td>160.5</td>
<td>228.9</td>
<td>151.3</td>
</tr>
<tr>
<td>80</td>
<td>26.7</td>
<td>143.6</td>
<td>86.7</td>
<td>175.4</td>
<td>165.8</td>
<td>236.1</td>
<td>156.3</td>
</tr>
<tr>
<td>82</td>
<td>27.8</td>
<td>148.4</td>
<td>90.0</td>
<td>181.0</td>
<td>171.2</td>
<td>243.6</td>
<td>161.3</td>
</tr>
<tr>
<td>84</td>
<td>28.9</td>
<td>153.2</td>
<td>93.5</td>
<td>186.7</td>
<td>176.8</td>
<td>251.2</td>
<td>166.5</td>
</tr>
<tr>
<td>86</td>
<td>30.0</td>
<td>158.2</td>
<td>97.0</td>
<td>192.5</td>
<td>182.4</td>
<td>258.9</td>
<td>171.8</td>
</tr>
<tr>
<td>88</td>
<td>31.1</td>
<td>163.2</td>
<td>100.6</td>
<td>198.4</td>
<td>188.2</td>
<td>266.8</td>
<td>177.2</td>
</tr>
<tr>
<td>90</td>
<td>32.2</td>
<td>168.4</td>
<td>104.3</td>
<td>204.5</td>
<td>194.1</td>
<td>274.9</td>
<td>182.7</td>
</tr>
<tr>
<td>92</td>
<td>33.3</td>
<td>173.7</td>
<td>108.1</td>
<td>210.7</td>
<td>200.1</td>
<td>283.2</td>
<td>188.4</td>
</tr>
<tr>
<td>94</td>
<td>34.4</td>
<td>179.1</td>
<td>112.0</td>
<td>217.0</td>
<td>206.3</td>
<td>291.6</td>
<td>194.1</td>
</tr>
<tr>
<td>96</td>
<td>35.6</td>
<td>184.6</td>
<td>115.9</td>
<td>223.4</td>
<td>212.5</td>
<td>300.3</td>
<td>200.0</td>
</tr>
<tr>
<td>98</td>
<td>36.7</td>
<td>190.2</td>
<td>120.0</td>
<td>230.0</td>
<td>219.0</td>
<td>309.1</td>
<td>206.0</td>
</tr>
<tr>
<td>100</td>
<td>37.8</td>
<td>195.9</td>
<td>124.2</td>
<td>236.8</td>
<td>225.5</td>
<td>318.1</td>
<td>212.1</td>
</tr>
<tr>
<td>102</td>
<td>38.9</td>
<td>201.8</td>
<td>128.4</td>
<td>243.6</td>
<td>232.2</td>
<td>327.2</td>
<td>218.4</td>
</tr>
<tr>
<td>104</td>
<td>40.0</td>
<td>207.7</td>
<td>132.7</td>
<td>250.8</td>
<td>239.0</td>
<td>336.6</td>
<td>224.8</td>
</tr>
<tr>
<td>106</td>
<td>41.1</td>
<td>213.8</td>
<td>137.2</td>
<td>257.8</td>
<td>245.9</td>
<td>346.2</td>
<td>231.3</td>
</tr>
<tr>
<td>108</td>
<td>42.2</td>
<td>220.0</td>
<td>141.7</td>
<td>265.1</td>
<td>253.0</td>
<td>355.9</td>
<td>237.9</td>
</tr>
<tr>
<td>110</td>
<td>43.3</td>
<td>226.4</td>
<td>146.4</td>
<td>272.5</td>
<td>260.3</td>
<td>365.9</td>
<td>244.7</td>
</tr>
<tr>
<td>112</td>
<td>44.4</td>
<td>232.8</td>
<td>151.1</td>
<td>280.1</td>
<td>268.6</td>
<td>376.1</td>
<td>251.6</td>
</tr>
<tr>
<td>114</td>
<td>45.6</td>
<td>239.4</td>
<td>156.0</td>
<td>287.9</td>
<td>275.1</td>
<td>386.4</td>
<td>258.8</td>
</tr>
<tr>
<td>116</td>
<td>46.7</td>
<td>246.1</td>
<td>160.9</td>
<td>295.8</td>
<td>282.8</td>
<td>397.0</td>
<td>265.8</td>
</tr>
<tr>
<td>118</td>
<td>47.8</td>
<td>253.0</td>
<td>166.0</td>
<td>303.8</td>
<td>290.6</td>
<td>407.8</td>
<td>273.2</td>
</tr>
<tr>
<td>120</td>
<td>48.9</td>
<td>260.0</td>
<td>171.2</td>
<td>312.1</td>
<td>298.6</td>
<td>418.8</td>
<td>280.6</td>
</tr>
<tr>
<td>125</td>
<td>51.7</td>
<td>278.0</td>
<td>184.6</td>
<td>333.3</td>
<td>319.2</td>
<td>447.4</td>
<td>299.9</td>
</tr>
<tr>
<td>130</td>
<td>54.4</td>
<td>296.9</td>
<td>198.7</td>
<td>355.6</td>
<td>340.7</td>
<td>477.4</td>
<td>320.2</td>
</tr>
</tbody>
</table>