V-Cube™

Floor-by-floor, Vertical Self-contained System

Installation, Operation and Maintenance Instructions Manual

Mammoth®
a Nortek Air Solutions Brand

Capacities: 9–150 tons

Table of Contents

Nomenclature

Model Indicator
V – V-Cube

Volume Control
V – Variable air volume C – Constant air volume

Condenser
N – No cooling
Y – Chilled water cooling
X – Dx without WiSE coil W – Dx with WiSE coil
Z – Remote condenser A – Airside economizer

Nominal Tonnage

Number of Compressors
0 – Air handler T – Tandem compressors H – Heat pump

Voltage
F – 208-230/3/60 L – 220-240/3/60 G – 460-480/3/60
K – 575/3/60 J – 380-415/3/50

Heating Type
E – Electric H – Hot water
S – Steam X – No heat

Frame Size
S – Small M – Medium
L – Large T – Tall

Control Panel Location
L – Left handed unit
R – Right handed unit

V	V	Y	000	0	G	S	M	L

Safety Considerations

Warning, Caution and Important notes appear throughout this manual in specific and appropriate locations to alert Installing Contractors and maintenance or service personnel of potential safety hazards, possible equipment damage or to alert personnel of special procedures or instructions that must be followed as outlined below.

⚠ WARNING

Identifies an instruction which, if not followed, might cause serious personal injuries including possibility of death.

CAUTION

Identifies an instruction which if not followed, might severely damage the unit, its components, the assembly or final installation.

IMPORTANT

Indicates supplementary information needed to fully complete an instruction or installation.

Hazards may exist within this equipment because it contains electrical and powerful moving components. Only qualified service personnel should install or service this equipment. Untrained personnel can perform basic maintenance such as maintaining filters. Observe precautions marked in literature and on labels attached to the unit. Follow all safety codes.

⚠ WARNING

Disconnect the main power switch to the unit before performing service or maintenance. Electric shock can cause personal injury or death.

⚠ WARNING

Equipment roof, external components/assemblies (hoods, louvers, dampers, pipe chase, etc.) and internal components/assemblies (filter racks, fans, supports, etc.) are unsafe surfaces to walk and work on. Proper personnel supports and ladders must be used. If not followed, serious injuries may occur, including possibility of death.

General Information

This manual is designed to provide general information on the common operation of all standard and optional components that may have been installed in the unit. Note that some sections of this manual may not apply to your unit. This manual has been designed for a general purpose and describes all options offered by Mammoth that could be included in the unit. Consult the manual from the Component Manufacturer if more detailed technical information about a specific component is required.

All documentation that was specifically designed for your unit has been included in the pocket of the control panel, including (and if applicable):

- Mechanical drawings
- Unit nomenclature
- Electrical schematics
- Sequence of control
- Variable Frequency Drive (VFD) manual and CD (when supplied)
- DDC controller documentation (when supplied)
  - Controller user's manual
  - Communication protocol documentation
  - Hardware documentation
  - Keypad documentation

Recommended Spare Parts

Spare parts should be ordered at the time the installation is accepted by the Owner. Spare parts will reduce the down time in the event of a failure. The list of spare parts outlined below is considered minimal. Installation in remote locations or when the operation of heating equipment is essential may require more spare parts than listed. Please contact the Service Department at Nortek Air Solutions Canada for recommendations.

Minimum spare parts include:

- One matching set of fan belts (belt driven fans only)
- One set of filters
- One set of shell and tube condenser head gaskets per condenser (water cooled units only)

Unit Inspection on Arrival

Remove plastic wrapping, protective coverings and panels, securing latches, etc. to inspect the equipment exterior and interior for any damage that may have occurred during unit shipment and for shipped loose parts. Ensure there is no damage to any protruding exterior components such as door handles, disconnect switch handle, etc., or to internal components such as fans, motors, dampers and drains. File a claim with the shipping company if the unit is damaged. Check the packing slip against all items received. If any items are missing sign the carrier's bill of landing with the notation "Shipment Received Less Item #_____." Contact the factory immediately if damage is found. No return shipment will be accepted without authorization.

Unit Application Limitations

CAUTION

Mammoth equipment is not designed to be used for temporary heating, cooling and/or ventilation during construction.

Using Mammoth units for temporary ventilation during construction is subject to the unit warranty terms and should be reviewed carefully before proceeding, as this may void the standard warranty conditions.

Fine dust, larger particulate matter, solvents, varnishes and other chemicals may cause filter clogging and elevated cabinet pressures, higher power consumption and possible irreparable damage to a variety of other key components that may be present in the system. Potential damages include, but are not limited to, these examples.

Installation

Unit Location Requirements

Consult local building codes and electrical codes for special installation requirements and note additional requirements listed in this manual. In choosing the installation location of the unit, consider the following factors:

- The unit should be installed to allow easy access for maintenance and for systems operation.
- Clearance around the unit should be per the recommended clearances indicated on the mechanical/submittal drawings (varies per unit frame size) in order to allow easy access for maintenance and for system operation. For clearances to remove specific components, please consult factory.
- Locate the unit in an area requiring the least amount of ductwork and direction changes to allow optimum performance, to reduce pressure loss and to use less electricity to achieve proper ventilation. Ductwork must be in accordance with ducting mechanical rules to prevent sound issues and system effects.
- The unit should be mounted on a level foundation to allow condensation to flow into internal drains. The foundation must provide adequate continuous support to the full perimeter of the base and all cross members requiring support to minimize deflection of the unit base frame to not more than 1/16" [1.6 mm] over the entire length and width. In addition to these recommendations, a Structural Engineer must be involved to properly size supporting structural elements.
- Once the unit is in place within the mechanical equipment room, mount the unit on a housekeeping pad of sufficient height in order to allow for drain trap height and condensate lines to slope toward the building drain; install condensate pumps to reduce height of the housekeeping pads or drill holes in the concrete pad or mechanical room floor for sufficient trap height.

Rigging, Lifting and Assembling

IMPORTANT

- Carefully read all the instructions contained herein. Before proceeding with any work, correlate these instructions with the information provided on the curb and equipment shop drawing for the specific project.
- These instructions outline the suggested method of rigging, lifting and installing a Mammoth unit. All local codes and fire regulations must be verified and adhered to by the Installing Contractor.
- Before assembling, hoisting or setting any pieces of the supporting curbs or units, verify that the proper unit is being directed to the correct location, as designated by the architectural and engineering design drawings.
- Safety first – ensure that all safety practices recommended by local safety associations are continuously in use.
- If any questions arise during the installation procedure, please contact the factory.
- The Installing Contractor is responsible for the unit being air- and water-tight including all section joints on the unit.
- All holes that have been made by the Installing or Electrical Contractor after receiving and installing the unit must be well sealed to prevent air and/or water infiltration.

Rigging, Lifting and Assembling Equipment

All rigging equipment and labor (as applicable) is provided by the Installing Contractor as detailed below. It is highly recommended that extra quantities of all items listed be on hand. The rigging procedure and/or equipment used to lift the unit may differ depending on the physical dimensions of the unit, its location, the jobsite, the Installing Contractor and Crane Operator preferences.

- Lifting crane of the appropriate capacity.
- Adjustable spreader bars.
- Cables (cables, chains or straps).
- All tools required to pull the sections together (chains, chain blocks, chain type come alongs, etc.).
- All construction equipment and labor required to complete the work according to local codes.
- Condensate and/or P-trap piping hardware.
- All tools and materials required for level unit installation.

Installation and Assembly Materials for Multi-section (Modular) Units

All materials for assembling a multi-sectional unit as detailed below and per the instructions that follow are supplied by Mammoth and located inside one (or more) of the unit sections, where this (yellow) label, as shown below, is applied on the door.

IMPORTANT

- Installation and assembly materials are in this section.
- Before setting unit on structural support, read and follow the Rigging, Lifting and Assembling instructions in the Installation, Operation and Maintenance Instructions Manual.

- ADBOND 1465 acoustical butyl sealant (or equivalent) (applied to top perimeter of structural steel support, housekeeping pad or to the top perimeter joint of a horizontally split indoor unit lower section just prior to unit installation). The use of ADBOND 1465 acoustical butyl sealant (or equivalent) is required to create a proper seal to minimize the risk of water infiltration and/or to ease section movement when pulling modules together. Do not use the butyl sealer on the exterior split section joints or exposed surfaces as it remains pliable, sticky and should it become smeared is difficult to clean.
- Polyvinyl gasket with adhesive strip (½" x 1½" [13 x 38 mm] x required length) applied between unit sections (for split section joints and duct opening connections).
- 3/8" x 7" Grade 5 1¼" thread length zinc plated bolts, with two washers and one nut each (to secure sections together).
- Adseal 1800 series (from Adchem Adhesives) clear silicone-based sealant or equivalent (for side joint and top joint).
- Self-drilling 5/16" hex head #12-14 x 1" zinc plated screws with rubber washer.
- Junction plates (already installed on the unit)

Rigging, Lifting and Assembling Instructions

Depending on size, the unit or unit sections of a multi-section (modular) unit will arrive at the jobsite on a standard flatbed or special low bed trailer. Each unit or unit section is identified with labels, as per the mechanical drawings. At ground level, ensure that any crating used for shipping purposes is removed if there is a possibility that it will interfere with the placing or assembling of the unit or unit sections on the structural steel or housekeeping pad.

IMPORTANT

For multi-section (modular) units, make certain to always rig, lift and install an end section with bottom duct connection first.

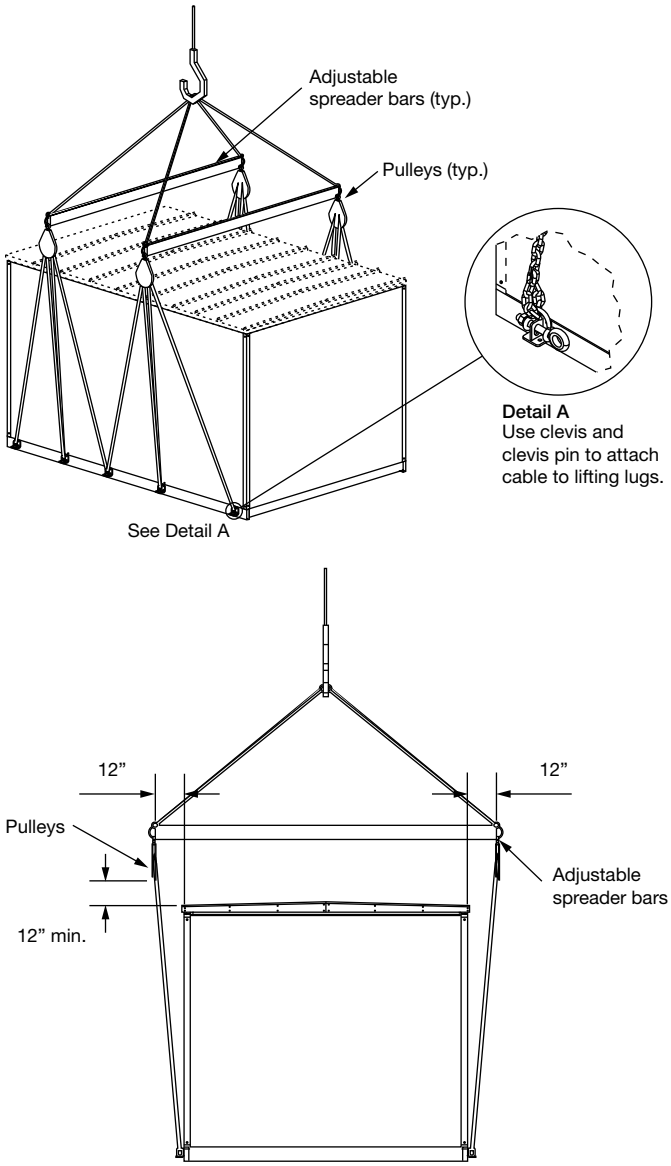
Unit or unit sections shall be lifted by cables attached to all the lifting lugs. Consult the mechanical drawings located in the pocket of the control panel for the number of lifting lugs, number of sections and unit weight. For multi-section (modular) unit check for additional lugs located between split sections. Lifting lugs are factory bolted to the unit or unit section base.

CAUTION

All lifting lugs provided **must** be used when rigging units or unit sections. Rigging and lifting unit or unit sections without using all lifting lugs provided will compromise the structural integrity of the unit or unit section. **Never** lift, rig or ceiling suspend from the top of the unit or unit sections. Using a forklift or similar device for moving, lifting or rigging unit or unit sections is prohibited. The use of a forklift or other similar device is only allowed for modular unit sections that are mounted on wooden skids within the factory prior to shipment. The sections must be forklifted individually along its longest side only.

When lifting the unit or unit sections, use adjustable spreader bars, pulleys, cables (straps or chains) in order to properly distribute the load, applying an even vertical lifting force only at all the lifting lugs to prevent structural damage to the unit or unit section or prevent cables from rubbing against the cabinet (see Figure 1). Provide additional blocking and coverings (as required) to prevent damage to the unit finish and/or components. The adjustable spreader bars are required to maintain a clearance between the cables and the unit or unit section of at least 12” [305 mm] beyond the sides. Mammoth will not be responsible for any damage caused to the unit casing during the lifting process. Main areas where damage may occur are: electrical panels, filter gauges, roofing corners, door handles and paint finish. The lifting point must be at the center of gravity to ensure that the unit or unit section is level during hoisting and prior to setting. When commencing to hoist, take up the slack in the hoisting cables slowly and gradually increase the cable tension until the full unit or unit section weight is suspended. Avoid sudden, jerking movements. Do not permit the unit or unit section to be suspended by the lifting lugs for an extended period of time. Once the unit or unit section leaves the trailer, ensure it is level at all times.

Figure 1: Use adjustable spreader bars, pulleys and cables attached to all lifting lugs to apply an even lifting force.



Assembling a Multi-section (Modular) Unit

Special attention must be taken to ensure that a multi-section (modular) unit has an air- and water-tight seal at every section split. Follow the next set of instructions for assembling a multi-section (modular) unit.

1. The complete fan section (non-compressorized unit) **or** the bottom half compressor/condenser section should be set in place first. Remove the yellow lifting lugs located on the section joint (if any) once the first section is set in place.

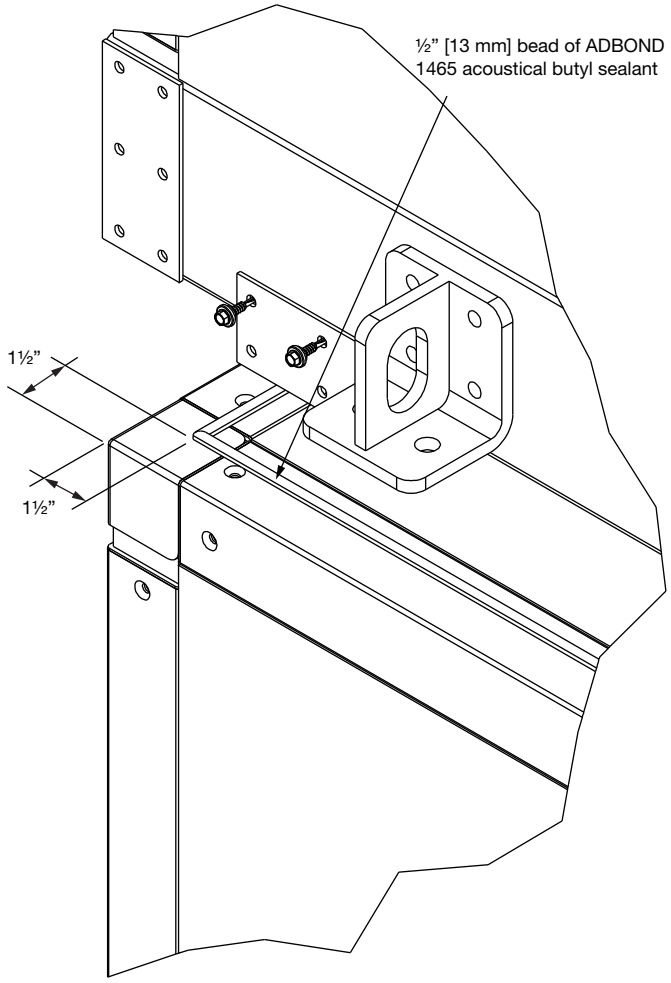
IMPORTANT

Yellow lifting lugs located on the section joint (if any) must be removed once the first section is set in place to allow the next section to be pulled to the first.

The complete fan section (non-compressorized unit) or the bottom half compressor/condenser section base must be fastened to the structural steel or pad to prevent this end section from moving when pulling sections together. Fastening method must be determined by the Installing Contractor. The lifting lugs on the outside perimeter may be used or removed with bolts and internal nuts used to fasten unit to structural steel or pad. All bolts should be returned and sealed.

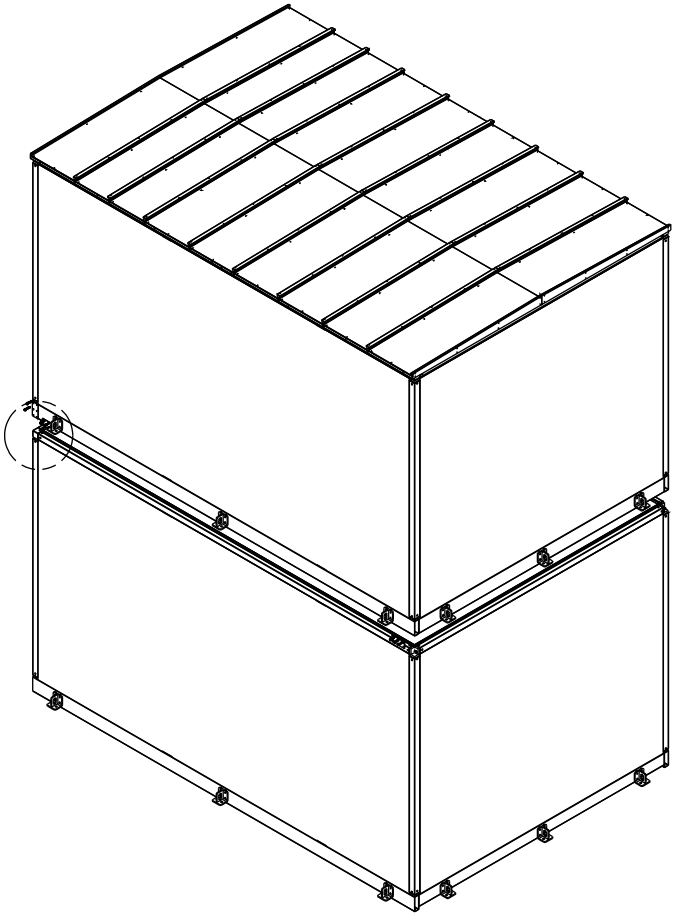
2. For a horizontally split indoor unit or section:
   a. Apply a continuous ½" [13 mm] bead of ADBOND 1465 acoustical butyl sealant on the top perimeter of the lower or bottom section 1½" [38.1 mm] from the outer edge as shown in Figure 2a.

Figure 2a: Apply a continuous ½" bead of butyl sealer on the top perimeter of the lower or bottom section.



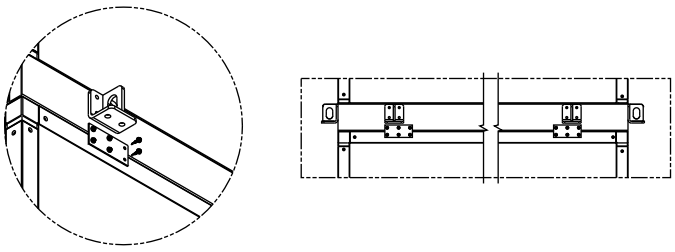
b. Set the upper or top section over the lower section lining up the bolt holes in the junction plates for a horizontally split indoor unit or section (see Figure 2b).

Figure 2b: Set the upper or top section over the lower section, lining up all the bolt holes in the junction plates.



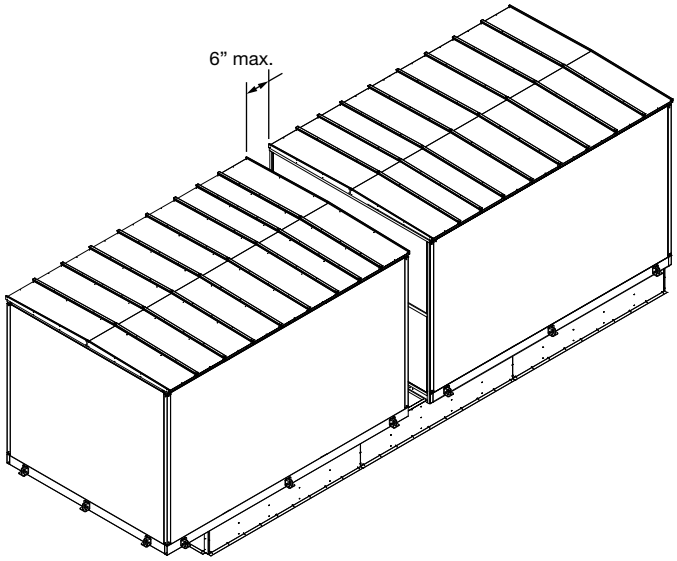
c. Remove the six self-drilling 5/16" hex head #12-14 x 1" screws with rubber washer and the junction plates, and use those to secure the upper or top section to the lower or bottom section as shown in Figure 2c.

Figure 2c: Remove the six self-drilling 5/16" hex head #12-14 x 1" and the junction plates, and use those to secure sections.



3. Set the second or DX evaporator cooling coil section approximately 6" [152 mm] from the first section (see Figure 3). If second section has a horizontal split, the top section must be installed as per procedure #1 above before proceeding. Remove the yellow lifting lugs located on the section joints (if any) from the second section to allow sections to be pulled together.

Figure 3: Set the next section approximately 6" [152 mm] from the first section.

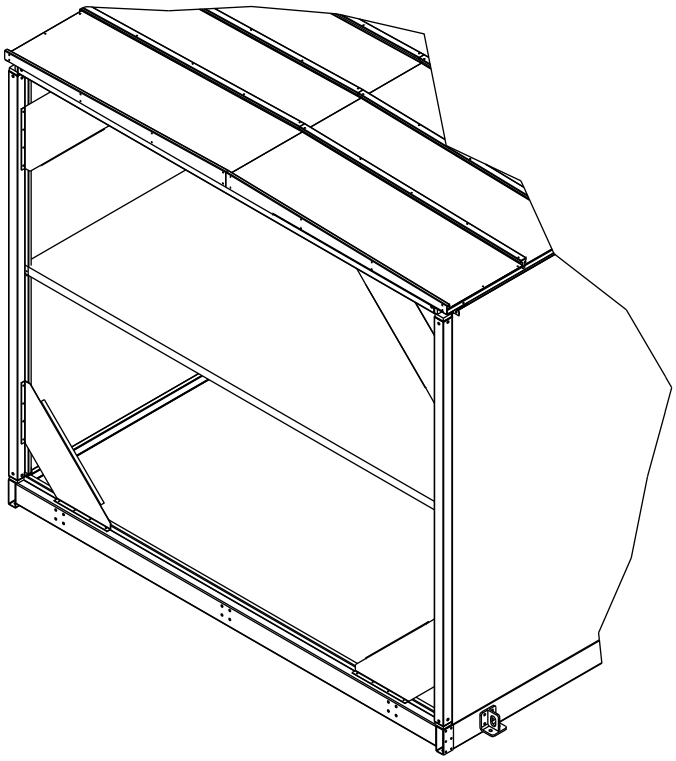


4. Corner reinforcement brackets or angle bars may have been used to support multi-section (modular) unit walls during transportation, rigging and lifting at the split. The brackets shown in Figure 4 are for larger units. Simple angle bars are used for smaller units (not shown). The corner reinforcement brackets or angle bars are no longer required after rigging and lifting and must be removed.

IMPORTANT

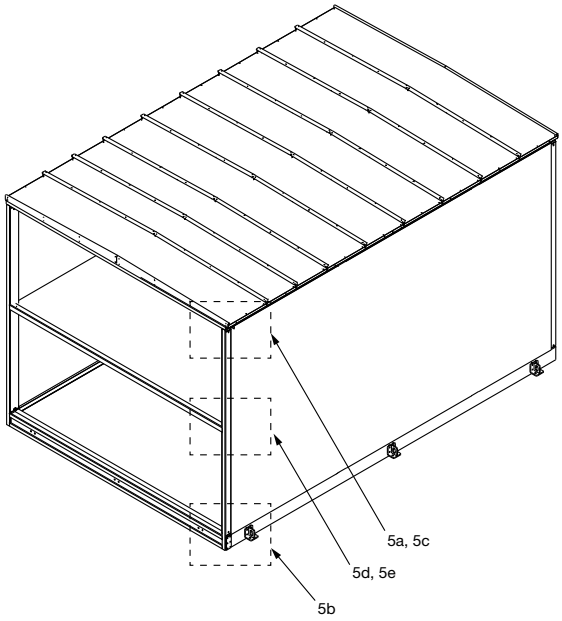
After the corner reinforcement brackets or angle bars have been removed from the split section, set the screws along with the rubber washers that were holding the brackets or angle bars back in place for water-tightness.

Figure 4: Corner reinforcement brackets or angle bars to be removed from the split section. Reset the screws with rubber washer in place for water-tightness.



5. Verify that these two sections are aligned square at the joint in all three directions.
6. Install the ½" x 1½" [13 x 38 mm] polyvinyl gasket with adhesive strip directly on one side of the split section perimeter frames and middle interior partitions as shown in Figure 5a through Figure 5d.

Figure 5: General gasket layout



IMPORTANT

Make sure to have full contact between strips wherever a discontinuity is present, for air- and water-tightness.

Figure 5a: Install a polyvinyl gasket strip on each vertical outside wall ¼" [6.4 mm] from the outside side edge from top to bottom of the side joint. When compressed, a small gap will remain which will allow the Adseal 1800 series silicone-based sealant or equivalent to seal the vertical side edges (explained in Figure 7c).

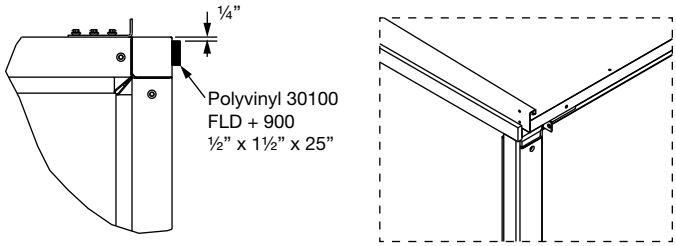


Figure 5b: Install two horizontal polyvinyl gasket strips along the base frame, one at the top and one at the bottom of the base frame between the two vertical side gasket strips so there is full contact between gasket strips for air- and water-tightness.

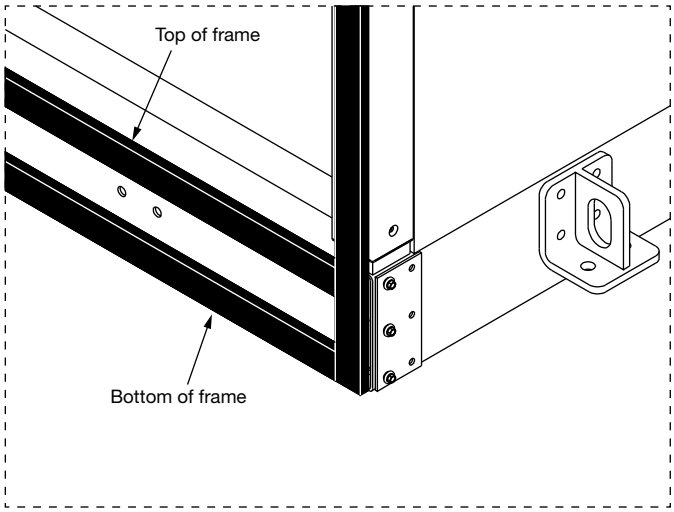


Figure 5c: Install one horizontal polyvinyl gasket strip along the top frame between the two vertical side gasket strips so there is full contact between gasket strips for air- and water-tightness.

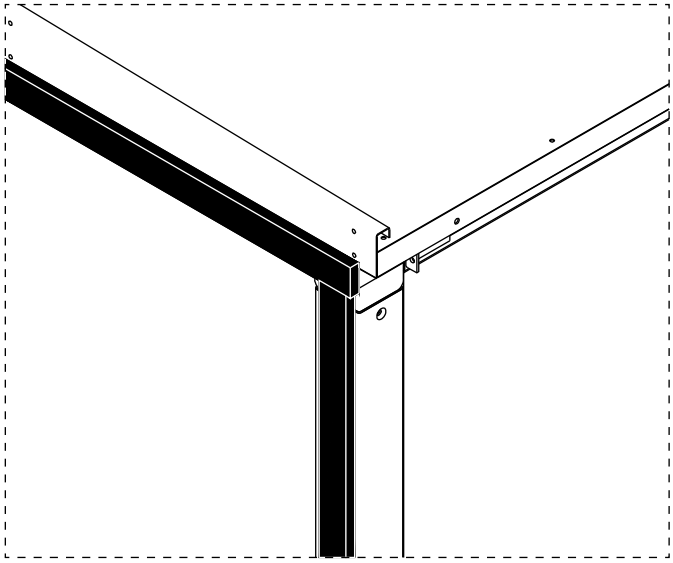


Figure 5d: Where two or more internal air tunnels/ corridors are present, install the gasket strips on the middle internal horizontal and/or vertical partition(s)/ divider(s), between the perimeter gasket strips so there is full contact between gasket strips for air- and water-tightness.

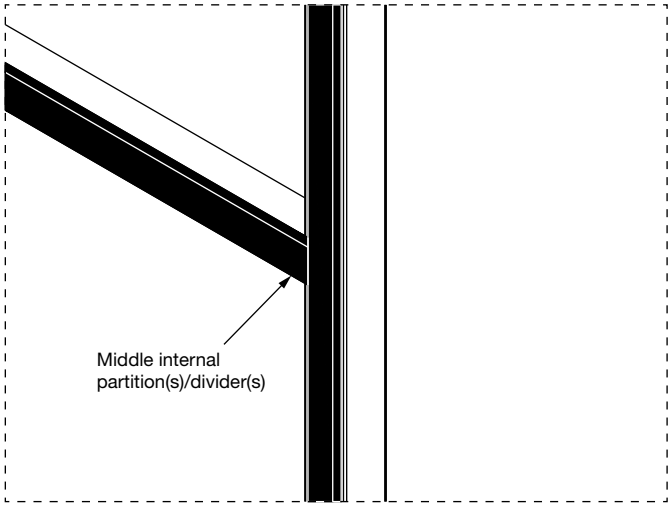
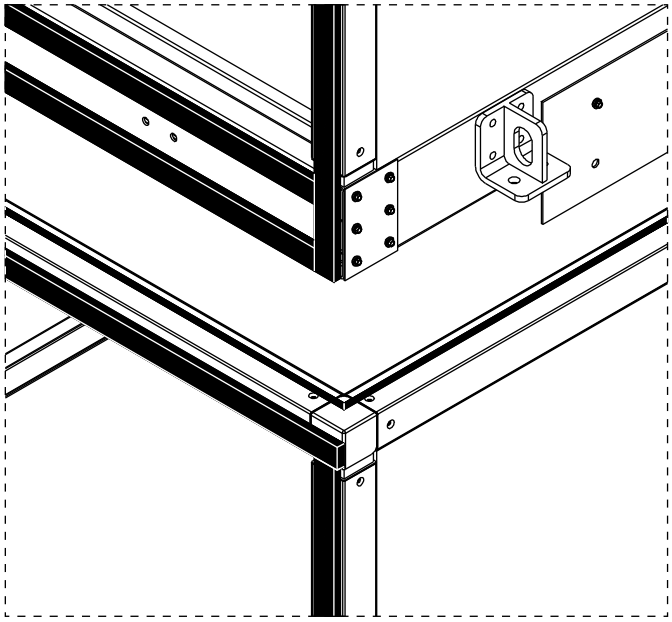


Figure 5e: Where a multi-sectional indoor unit with vertical and additional horizontal splits join, the middle internal horizontal partition will require three gaskets—one at the top of the bottom section and two at the bottom frame of the top section.



Pulling Multi-section Units Together

7. Use tools (chains, chain blocks, chain type come along, etc.) connected to the side lifting lugs (attached to the base) on both sides of the unit to pull the second or next section to the first end section evenly until both sections are ¼" [6.4 mm] apart on the full joint perimeter as in Figure 6. Keep the tools (chains, chain blocks, chain type come along, etc.) in place until further notification. Remove any exterior lifting lugs that interfere with the chains for pulling sections together. When joining sections together, always apply the pulling force to the lifting lugs attached to the unit structural base, never to the iron angle fixed near the corner posts and pull uniformly from both sides of the unit section. The butyl sealer previously applied on the top surface will allow the unit section to slide into position.

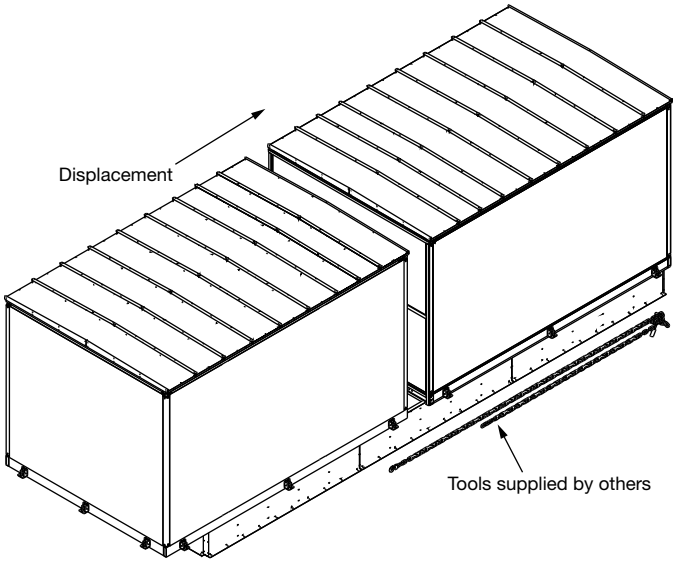
IMPORTANT

Unit sections must be drawn together using the lifting lugs attached to the unit structural base only.

CAUTION

Do not use the roof frame iron angle to pull sections together as this may cause the corner posts to warp and break their air- and water-tight seal.

Figure 6: Use tools (chains, chain blocks, chain type come along, etc.) hooked to the unit lifting lugs attached to the structural base on both sides of the unit to pull the second or next section to the first section evenly.

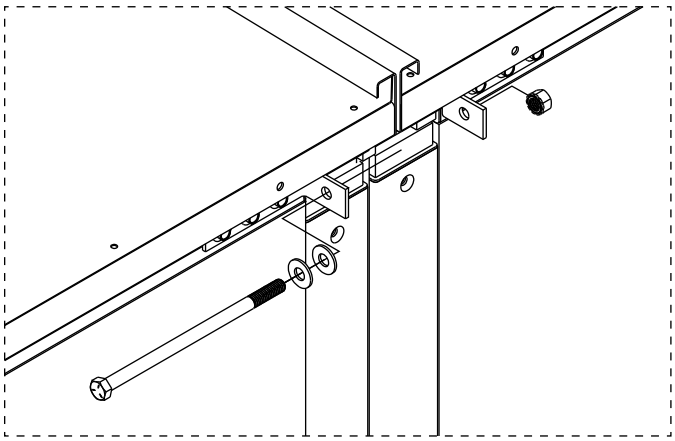


8. With the sections pulled together, use the 3/8" x 7" bolts, nuts and washers to secure the top of the sections together as in Figure 7a. Gradually tighten the bolt until gasket is compressed within ¼" [6.4 mm].

CAUTION

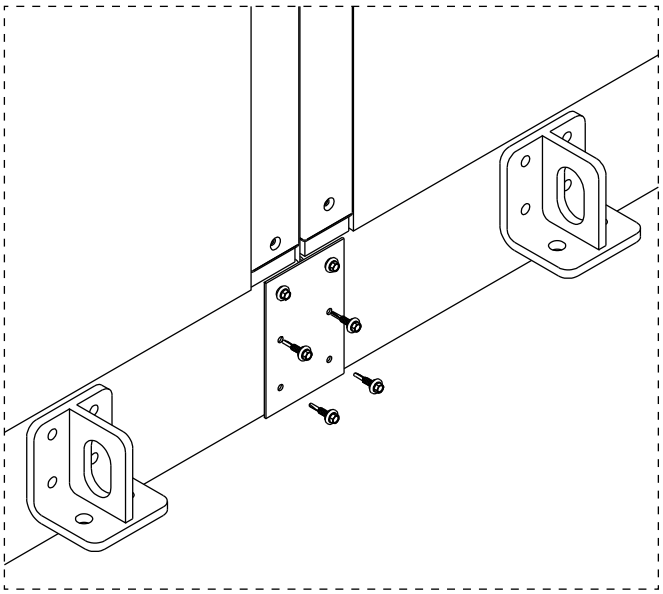
Do not over tighten the side bolts as this may cause the angle iron to bend and squeeze the 3/8" x 7" bolts inside the angle iron.

Figure 7a: Use the 3/8" x 7" bolts, nuts and washers to secure the top of the sections together.



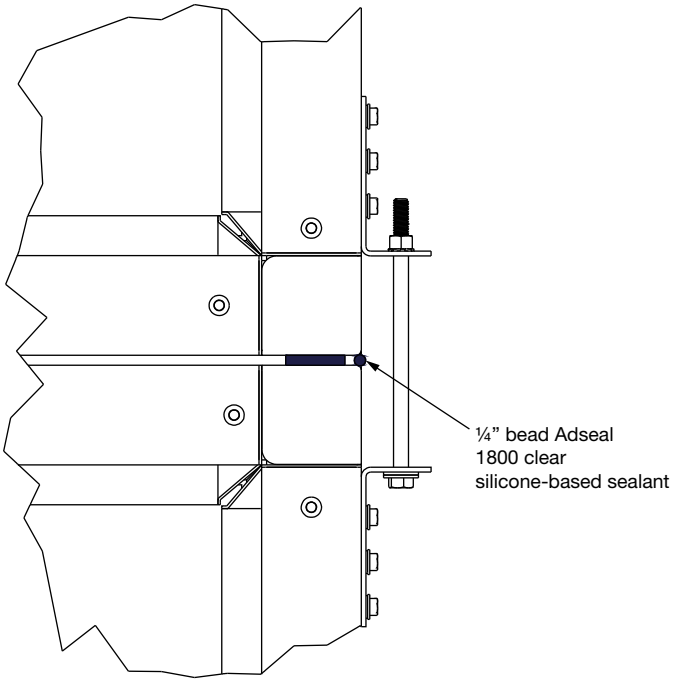
9. Remove the six self-drilling 5/16" hex head #12-14 x 1" screws with rubber washer and the junction plate already installed on one of the sections' structural base, and use those to fix the two sections together as in Figure 7b.

Figure 7b: Use the junction plates already installed on one of the sections' structural base to fix the two sections together.



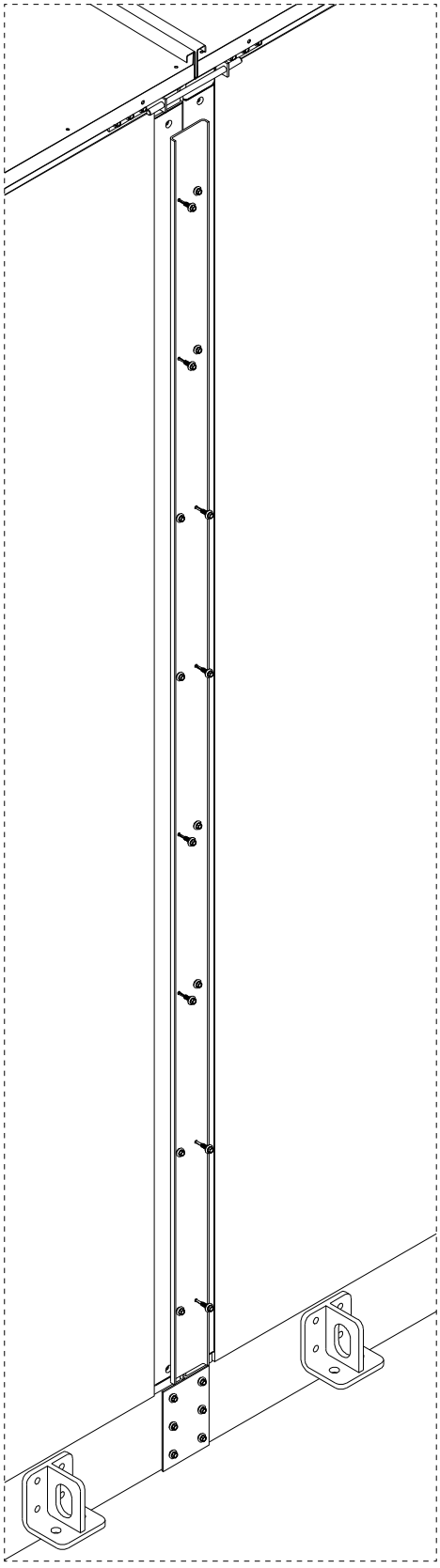
10. After two sections are assembled, verify that the assembly is level and square. If an adjustment is required, make certain to address it immediately, not at the end of the final assembly.
11. If multi-section unit has more than two sections follow Steps 1 through 10 for each additional section, always pulling the next section from the first end section.
12. Apply a generous bead of Adseal 1800 series clear silicone-based sealant (or equivalent) to the exterior side frame joint seams, from the roof to the junction plate fixed on the structural base, sufficiently to completely cover the section split gasket and in such a way that the silicone bead meets with both frames as in Figure 7c. The bead of clear silicone-based sealant should fill the ¼" gap, as shown in Figure 7c.

Figure 7c: Apply a continuous bead of Adseal 1800 clear silicone-based sealant (or equivalent) to the exterior side frame joints and for indoor units along the top frame joints, from the roof to the junction plate fixed on the structural base.



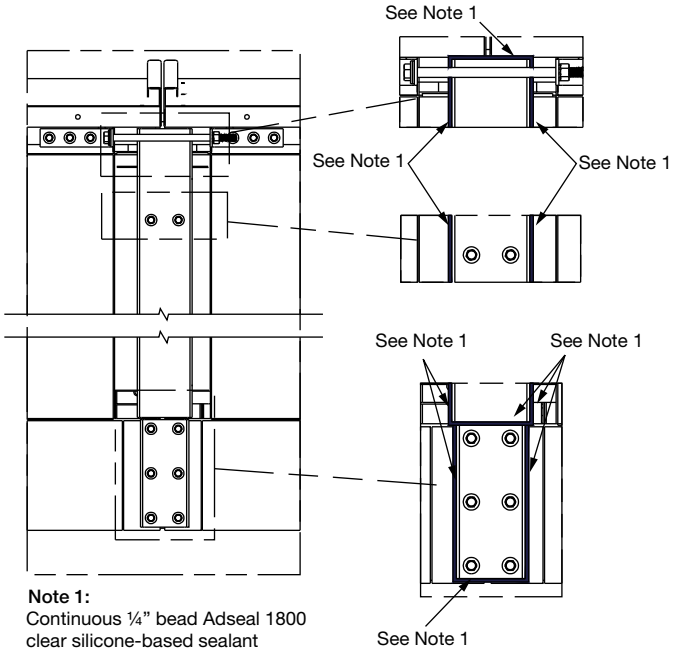
13. Remove the six self-drilling 5/16" hex head #12-14 x 1" screws with rubber washer and the junction plate already installed on one of the sections' walls, and use those to fix the two sections together as in Figure 8a. At this moment, the tools (chain, chain blocks, chain type come along, etc.) can be removed.

Figure 8a: Use the junction plates already installed on one of the sections' walls to fix the two sections together.



14. Apply a generous bead of Adseal 1800 series clear silicone-based sealant (or equivalent) around the junction plate previously installed on the exterior frames and the junction plate previously installed on the structural base as in Figure 8b.

Figure 8b: Apply a generous bead of Adseal 1800 series clear silicone-based sealant (or equivalent) around the junction plate previously installed on the exterior frames and the junction plate previously installed on the structural base.



15. All lifting lugs removed on the exterior of the base for pulling sections together must be returned, or if not desired the bolts must be set back in place. Once removed the bolts must be returned and sealed with clear silicone-based sealant for water-tightness. All other lifting lugs from the unit base may be removed if desired, or left in place. When removing lifting lugs on the exterior of the base, set the bolts back in place and seal with clear silicone-based sealant for water-tightness.

16. Touch-up paint for scratches or marks to the external finish incurred during shipment or installation can be obtained in the fastest amount of time in bulk or spray cans from a local paint supplier by providing the universally recognized RAL code. To match the Venmar CES standard grey specify color RAL K7 Classic #RAL7001, two-component polyurethane paint with a gloss of 30+/–4.
Paint cans (11 ounces) matching the Venmar CES grey can also be obtained in a slower amount of time by contacting the following paint suppliers listed below and providing the item number, item name and Vendor number below or through Venmar CES After Sales Service by: email to Tech Support at venmarservice@venmarces.com, fax 899-319-2612 or phone 1-866-483-6627.

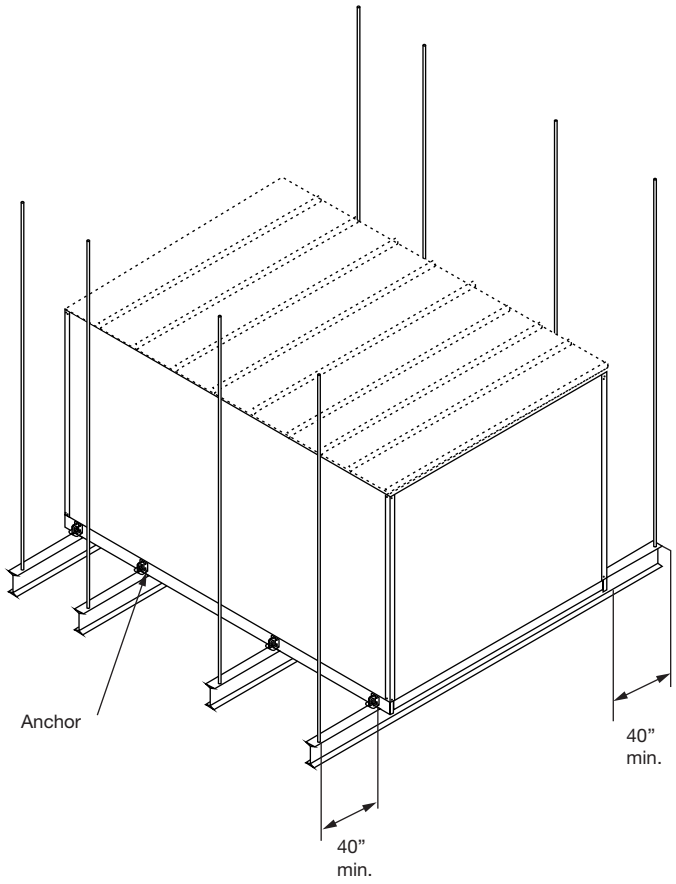
In Canada
Sunamco
360 Gleme Rue C.P 280
Daveluyville, Quebec G0Z 1C0
Phone: 1-866-815-4080
Contact: Audrey Mallhot
Item number: 500049624
Item name: Canette peinture grise RAL7001
Vendor number: VEN00002429

In USA
Using the universally recognized RAL code (RAL7001), Venmar CES grey paint can be obtained from your local supplier.

Suspended Unit Installation

To install units that will be permanently suspended, the units must be set on structural steel beams that are supported by vertical rods. Mammoth recommends beams under the full perimeter and all cross members requiring support. In addition to these recommendations, a Structural Engineer must be involved to properly size the supporting structural elements. Note that the locations of the beams shall be coordinated with the location of access doors to prevent any interference (see Figure 9). Single section unit shown; for multi-sectional unit suspension, consult factory.

Figure 9: Indoor suspended installation



Field Fabricated Ductwork

On indoor horizontal or indoor vertical duct connections, make connections to the casing by applying Adseal 1800 silicone-based sealant or equivalent around the connection and screwing flanged ducts directly to the casing and/or flange with self-drilling sheet metal screws. It is important to seal all duct connections to prevent air leakage and system performance problems. Ductwork must be supported by the building structure.

For duct connection sizes, see the mechanical drawings. Insulate and weatherproof all external ductwork, joints and roof openings with counter-flashing and mastic in accordance with applicable codes. Ductwork running through roof decks must comply with local fire codes. Ducts passing through unconditioned spaces must be insulated and covered with a vapor barrier. Flexible connectors should be installed close to the unit in the duct leading to occupied spaces to minimize noise transmission.

The ventilation system should be designed according to maximum airflow needs. To minimize noise level and loss of pressure, ducts should be designed for a maximum air velocity of 1,200 feet per minute, keeping the direction and transition changes to a minimum. To further reduce noise transmission, line the first 15 feet [4,572 mm] of duct with acoustic insulation. Elbows with a turning radius equal to or greater than one, or 90º elbows with turning vanes, should also be used.

Electrical Connections

⚠ WARNING

When installed, the unit must be electrically grounded in accordance with local codes or, in the absence of local codes, with the National Electrical Code, ANSI/NFPA70, and/or the Canadian Electrical Code CSA C22.1. Unit cabinet must have an uninterrupted, unbroken electrical ground to minimize the possibility of personal injury if an electrical fault should occur. Failure to follow this warning could result in the installer being liable for personal injury of others.

The unit is factory wired (unless otherwise specified) except for power connections, shipping split locations, shipped loose sensors/items or remote control options as indicated in the electrical schematics and sequence of control. The unit may or may not have an optional factory installed door interlocking disconnect in the control panel. If the unit control panel disconnect is not supplied the Electrical Contractor must provide and install disconnect outside of the unit as per local electrical codes and run the power supply wiring to the control panel.

- For multi-section (modular) units, the Electrical Contractor must join the low and high voltage wiring between unit sections at the junction boxes or extend coiled wiring.

IMPORTANT

Wire nuts and electrical butt connectors (if required) must be supplied by the Electrical Contactor.

- Check nameplate for correct power supply requirements.
- See electrical schematics and sequence of control located in the control panel pocket for field wiring of power connections, shipped loose sensors, items or remote control interlocks. The Electrical Contractor must locate, install and wire sensors, items or remote control interlocks as per electrical schematics and sequence of control.
- Numbered terminals strips are included in the control panel for ease of connection and service.
- All field wiring and components must comply with NEC and local requirements. In Canada, electrical connections must be in accordance with CSA C22.1 Canadian Electrical Code Part One.
- Install copper wiring of proper size to handle current load.
- Mounting of field provided components in the control panel is allowed as long as their space was considered during the submittal process. Non-considered electrical components are not allowed in the control panel. It is the responsibility of the Control Contractor to provide his own power source(s) for any field added electrical components. The control panel mounted transformers are not rated for external components power supply unless otherwise listed on the electrical schematics.

Electrical Field Connections

CAUTION

Electrical components and contacts must be protected from damaging metal shavings before drilling holes into the control panel. Use liquid-tight connections through the control panel and unit casing eliminating any water and air penetration.

Shipped loose sensors, items or remote control wiring can be located next to the power feed cable provided it is inserted in shielded cable that will protect it from electro-mechanical interference. Ensure the power feed cable ground is securely connected to the terminals located in the control panel.

Electrical Contractor must provide wiring for controls that are supplied optionally and shipped loose or field supplied. Mark the electrical schematic with the connections completed and leave them with the unit for start-up and service.

CAUTION

High voltage power lines, shipped loose sensors, items or remote control option field wiring entry points may only be field extended through the cabinet within designated areas. The unit cabinet and/or floor must be wisely penetrated in order to keep their integrity. Access openings in the floor can only be cut or drilled for piping and wiring (high and low voltage) in the designated rectangular areas within an upturned 1” [25.4 mm] flange as provided during the submittal process and located on the mechanical drawings. Access openings must be sized, field cut or drilled by the Installing Contractor within the rectangular flanged area then sealed air- and water-tight. If insulation was removed to create floor access openings, insulation must be put back in place to avoid condensation. **Do not** cut or drill holes through floor of unit in non-designated areas without consulting the factory first. The structural integrity of the floor may be compromised and possible leaks develop.

Coil or Water Cooled Condenser (WCC) Piping Connections

Units have the WCC supply and return line internally coupled (manifold) and piped to the unit exterior. The WCC connections shall have copper IPS connections. See the submittal drawings for size, location, flow rate, type of fluid, pressure drop information and components included and factory installed for the supply and return connections.

CAUTION

Internal coil (water, steam or non-integrated direct expansion), WCC piping connections within the unit may only be field extended through the cabinet within designated areas.

Connections to the unit coil (water, steam or non-integrated direct expansion, WCC or humidifier) are by others. Refer to the mechanical drawings and the instructions on the casing for correct orientation of external piping. External supply and return piping connection, provision, design and all other safety (such as dielectric couplings or other), freeze protection or electrical control requirements for system operation are the sole responsibility of the Installing Contractor and/or Design Engineer. Refer to ASHRAE handbooks and local building codes for correct piping and electrical control for proper installations. Refer to the mechanical drawings for coil performance design information. Refer to Victaulic installation instruction manual for proper water valve and coupling installation and assembly.

For WCC units, see Appendix A. See the piping schematics for optional piping components and sequence of operation for electrical control options or interlocks supplied with the unit.

CAUTION

A water and glycol mixture is used for factory tests and to prevent any possibility of freezing during transit and/or storage. In units that include factory installed water piping, some glycol may remain in the system. Flush the system in the field, prior to installation, if no glycol traces are desired. In low temperature applications, the water supply line and return line should be insulated to prevent condensate and an antifreeze solution should be used to protect water-to-refrigerant heat exchanger from freezing damage.

IMPORTANT

A hydrostatic test must be performed in the field by the Installing Contractor at 1.25 times the operating pressure on all equipment involving piping connections to verify that the installed unit and its connections to the network are free of leaks prior to the unit being set in operation. This test shall be performed after the unit is completely piped to the network and shall cover the connections between the unit and the network, as well as all internal components of the unit.

Condensate Drain Trap and Lines

Cooling coils, humidifiers or other options that can produce condensation are provided with a drain pan with a 1¼" [32 mm] MPT (Male Pipe Thread) drain connection. A drain trap and condensate line of equal size must be field provided by the Installing Contractor on the drain connections and coupled to the building drainage system to prevent air or sewer gases from being pulled into the unit caused by the negative (suction) pressure and forcing water out of the pan into the unit or from air escaping into the drain caused by positive pressure. Condensate piping can be steel, copper or PVC. See Appendix B for illustrations and dimensional information on positive and negative pressure trapping height. Slope the drain lines downward in direction of flow not less than 1/8" per foot toward the building drainage system; otherwise, use a condensate pump. Refer to local codes for proper drainage requirements. Installing a plug for cleaning of the trap is recommended. Fill the P-traps with water before starting the unit. Check and clear drains annually at start of cooling season. Drainage problems can occur should drains be inactive and dry out or due to reduced water flow caused by buildup of algae. Regular maintenance will prevent these from occurring.

Refrigerant Systems

On assembled units which are split for shipment or by customer request, where the refrigeration system is split, the refrigerant lines are capped at the splits, factory leak tested and charged with nitrogen. The type of refrigerant and charge is based on calculated volumetric capacity and stamped on the nameplate. The Installing Contractor is responsible for connecting the refrigerant lines, leak testing, evacuation, charging the refrigerant system and adjusting the charge.

On assembled units with split refrigerant systems where the condenser or condenser/compressor sections are remotely installed, the Installing Contractor is responsible for designing and completing the refrigerant system, calculating the charge, leak testing, evacuation, charging the refrigeration and adjusting the charge.

Refer to Appendix L for information on adjusting the refrigerant charge.

Start-up

Pre Start-up Check

Before requesting start-up, check that the installation is complete and unit is ready. Complete the pre start-up below (if items are applicable) and the checklist in Appendix C for each unit. For torque values on set screws, belt tension, etc., check under Maintenance and/or Appendix sections.

1. Check the electrical disconnect is in the 'Off' position.
2. Check the split section joints are properly installed on multi-section units.
3. Check that all holes that have been made by the Installing Contractor after receiving the unit in the casing, partitions or floor have been well sealed to prevent air and/or water infiltration.
4. Check the unit for obstructive packaging, objects near or in fans, dampers, etc.
   a. Check that the inside of the unit has been cleaned of all debris.
5. Remove all retaining bolts on fan isolation bases.
   a. Check that the fan impellers are rotating freely.
   b. Check fan impeller and drive set screws. Tighten if required.
   c. Check the fan bearing set screws or locking collars. Tighten if required.
   d. Check fan belt alignment and tension.
   e. Check that fan flexible joint connections are well attached.
6. Check that the air filters are installed and clean. Replace if necessary. See Appendix D for optional downstream high efficiency HEPA filter installation (if supplied).
   a. Check all face-mounted filters are attached with four clips each.
   b. Check each sliding filter has a retainer at the end track and well attached blank-offs.
   c. Check that the filter pressure differential gauges, switches or sensors are free of dirt and set at a value satisfactory to the end user to trigger a filter change.
7. Check coils if fins have been damaged in shipping, installation or building construction and are clean. Straighten fins with fin comb and clean coil if required (not applicable to brazed aluminum heat exchangers).
   a. Check all pipe connections are tight and that no damage has occurred during shipping or installation.
   b. Check that the piping to the coils and WSHP/WCC have been completed, piping lines have been flushed, filled, vented and tested at 1.25 times the operating pressure. Refer to Appendix A for piping installation and check that it is complete.
8. Scroll compressor RIS vibration isolator bolts are factory tightened to the correct torque setting for operation and do not require field adjustment.
   a. Check that refrigerant components and piping are in good condition and have no damage or leaks from shipping and/or installation.
   b. Check that the refrigerant lines are spaced at least 1" apart and from the compressor after shipping and installation.
   c. Check that the refrigerant line clamps are still secure and have their rubber lining.
9. Check motorized damper control arms, control rods and shafts for tightness.
   a. Check that non-motorized dampers rotate freely.
10. Check that ductwork is connected, complete and free of obstructions.
11. Check that condensate drain connections have been trapped, installed correctly and filled.
12. Check at all unit split sections that all factory internal high and low voltage wiring connections have been properly re-connected.
13. Check that all shipped loose or field supplied components have been correctly installed and wired.
14. Check that the wiring diagram has been marked up accordingly and left with the unit.
15. Check that all power supplies and control wiring have been inspected and approved by the Local Authorities having jurisdiction.
16. Check all factory and field wiring connections for tightness. Tighten if necessary.
17. Check that all settings of control are in accordance with the wiring schematic.
18. Check that all fuses are properly installed in holders.
19. Check the voltage at the disconnect switch against the nameplate and against phase-to-phase readings on three-phase. If the voltage is not within 10% of rated or 2% of phase-to-phase, have the condition corrected before continuing start-up.
20. Check that all field piping and venting installation and connections for the heating and cooling options have been completed and tested.
21. Set the heating and cooling enable switches to the 'Off' position.
22. If the unit is equipped with an electric coil, the installation and pre start-up checks must be completed per Appendix E.
23. Check that all safety switches, overloads or other manual reset devices are reset.
24. If the unit is equipped with compressors, power must be turned on with the unit in 'Off' mode for 24 hours before start-up. This will energize crank case heaters and assure no liquid refrigerant is present which could cause compressor damage or failure. Check that this has been completed.

Start-up Procedure

To ensure proper operation of each unit, qualified personnel should perform the start-up as outlined below (based on options included with unit) and complete the Start-up Form and Checklist in Appendix C for permanent record. A completed report and checklist will provide valuable information for personnel performing future maintenance.

IMPORTANT

- A completed copy of the Start-up Form and Checklist must be sent back to the factory for warranty validation and for factory assistance.
- General information on the factory installed and programmed DDC control system regarding the navigation and monitoring of the unit with the standard keypad are provided in separate documents. For more specific information regarding the sequence of control, the different options of control or network communications, see these documents included with the unit in the control panel pocket.
- If units are equipped with compressors, power must be turned on for 24 hours prior to a call for cooling, for the compressor crank case heaters to be energizing to prevent possible damage.
- Assembled units with integrated refrigerant systems (WCC, AC or WSHP) are factory leak tested, charged with refrigerant based on volumetric capacity and run tested prior to shipment with the type of refrigerant and charge stamped on the nameplate. As part of the start-up procedure, operate the refrigerant system near full load conditions in both heating and cooling modes and check sub-cooling and superheat against values in Appendix L, Table L1. If readings do not match, adjust the refrigeration charge. Refer to Appendix L for information on adjusting the refrigerant charge.

⚠ WARNING

- Electric shock can cause personal injury or death.
- Only qualified service personnel should install and service this equipment.
- The keypad must be used to check operation according to sequence and to adjust setpoints while power is on for start-up and while performing service.
- All units are factory run tested. Fans, compressors and condenser fans (if equipped and refrigerant piping is not split for shipment) are set up to run correct when power is connected. If any one fan is running backwards or compressor is making loud noises, disconnect power and switch two leads (on three-phase power) to ensure proper rotation and avoid damage. With multi-section units with split wiring connections check rotation of fans, compressors and condenser fans for correct rotation to ensure wiring connections are correct.

1. Before proceeding complete the pre start-up checklist.
2. Check that all access panels or doors are closed.
3. If units are equipped with compressors, feel the compressor crank cases. They should be warm if the disconnect has been on for at least 24 hours. This will assure that no refrigerant liquid is present in the crank case, which could cause compressor damage or failure to occur on start-up. Otherwise turn the main disconnect to the 'On' position.
4. The unit can be started by using the keypad and selecting the mode of operation from the Keypad Operation Guide and the Sequence of Operation. Disable the heating and cooling functions and set the unit to the occupied mode to bump start the fan wheel(s) to check their operation.
5. If units are equipped with dampers, check that dampers are operating properly.
6. Check that the fan wheel(s) are rotating in the correct direction.
7. Adjust the fan motor VFD(s) to the correct air volume/Hertz.
8. For occupied mode adjust outside and mixed or recirculation air damper positioners to achieve the required air volumes.
9. Re-check the voltage at the disconnect switch against the nameplate and against phase-to-phase readings on three-phase with all blower(s) operating. If the voltage is not within 10% of rated or 2% of phase-to-phase have the condition corrected before continuing start-up.
10. Check amperage draw to each motor on each phase against motor nameplate FLA. If significantly different, check ductwork static and/or take corrective action.
11. Before activating the compressor(s), ensure that any water shut-off valves are open and that water is circulating through the water-to-refrigerant heat exchanger. Check the incoming line water pressure to ensure it is within design and acceptable limits.
12. Enable the cooling mode of operation. Check if the sound of the compressor is normal or if there is excessive vibration.
13. Check all field and factory refrigerant and water piping connections for leaks and correct.
14. Operate the refrigerant system near full load conditions in both heating and cooling modes and check sub-cooling and superheat against values in Appendix L, Table L1. If readings do not match, adjust the refrigerant charge. Refer to Appendix L for information on adjusting the refrigeration charge.
15. On units with WCC, after a few minutes of operation:
    a. Check the supply discharge temperature status on the keypad for cooling air delivery. Measure the temperature difference between entering and leaving water. In cooling mode, the temperature

difference should be approximately 1.5 times greater than the heating mode temperature difference. For example, if the cooling temperature difference is 15°F [8.3°C], the heating temperature difference should be approximately 7°F to 10°F [3.9°C to 5.6°C]. Adjust the combination shut-off/balancing valve in the return line to a water flow rate which will result in the 7°F to 10°F [3.9°C to 5.6°C] difference. Alternatively, if a flow measuring valve or pressure gauge connections are included, take the flow reading or pressure drop compared to the submittal information and adjust the shut-off/balancing valve in the return line to the correct flow/pressure drop reading.

b. Measure the temperature difference between entering and leaving air and entering and leaving water. With entering water of 60°F to 80°F [15.6°C to 26.7°C], leaving temperature should rise through the unit (should not exceed 35°F [19.4°C]). If the air temperature exceeds 35°F [19.4°C], then the water flow rate is inadequate or the airflow rate may be low and a second check may be required after airflow balancing.

16. On units with electric heating coils, check supply air proving interlock switch setting to ensure minimum supply airflow prior to operation.
17. Enable heating options and check the operation according to sequence; for electric coils, see electric heating coil and controls information in Appendix E.
18. For electric heating coil option, check the amp draw on each stage, the operation of the sequence or SCR controller and the coil for any hot spots.
19. Check the operation of the control options provided on the unit.
20. Check the setpoints on the DDC Points Reference, adjust and record changes as required.
21. Check that air balance has been completed for both occupied and unoccupied operation.
22. When unit has achieved steady state take measurements and complete the readings section of the Start-up Form and Checklist in Appendix C. Send copy of the completed Start-up Form and Checklist to Nortek Air Solutions Canada to validate warranty. Maintain a copy of the report at the unit for future reference.
23. Once completed, return setpoints to original or required values, return the unit to the correct mode of operation and adjust the time clock if required.

Airflow Balancing

IMPORTANT

Before measuring airflows, the building must be in its normal state:

- Hermetically close doors and windows.
- Shut down hot air generators and combustion water heaters.
- Install all ventilation system components: filters, grilles, diffusers, etc.

For proper performance the unit must operate at the specified airflow rates as shown in the mechanical drawings. Unit fan speed(s) and damper positions are theoretically set at the factory based on the ductwork static pressures and flow rates specified in the mechanical drawings. If conditions change or verification is required, airflow measurements should be taken using AMCA suggested methods. This would normally be a velocity traverse measurement or flow measuring station (FMS) installed in the ducts. Should flow rates need to be reset, adjust the outside air, exhaust air or mixed air dampers, variable speed sheaves, VFD fan speed setpoint positions or change the sheaves.

Flow measuring stations (FMS) and magnehelic gauges can also be used to measure airflow. It is important to locate the FMS in the “warm side” ductwork to minimize the effect of differences in air density, especially when balancing during extremely cold outside conditions or to take temperature readings and make the necessary corrections if installed in the “cold side” ductwork. Air density variations can affect the FMS by more than 15%. The FMS should be located downstream in straight sections of duct and not immediately after fans or obstructions that will cause turbulent flow.

If the unit has been in operation before the air balancing, ensure the unit filters are clean or include pressure drop readings across the filter banks with the report.

Maintenance

Long-term Storage Maintenance Procedures

> **⚠ WARNING**
> Many of the following steps need to be performed with the unit **powered off** and locked out. Disconnect the main power switch to the unit before performing service and maintenance procedures.

Please refer to Appendix F for maintenance instructions to follow if the unit is to be stored for a period of time exceeding one month. Following the instructions in this appendix will assist in preventing potential unit damage that may result from an extended storage period.

Maintenance Summary Chart

Please refer to Appendix G for a recommended list of routine maintenance items and time intervals. A more detailed description of maintenance items follows.

Refrigerant Systems

Compressors

Scroll-type compressors are the most common type of compressor used by Mammoth. Other types of compressors are available upon request, if required. Maintenance and service on compressors must be completed by a licensed service mechanic. Provincial or state regulations frequently require such qualifications for compressor maintenance. If a compressor cycles, leaks or has any defects, contact the factory as soon as possible.

See Appendix A for compressor maintenance and troubleshooting refrigerant circuits, and Appendix L for adjusting refrigerant charge. Additional refrigerant troubleshooting issues can be found in Appendix K.

Water Cooled Condensers

Shell and Tube Condensers

Most integrated water cooled units contain shell and tube condensers. Periodically, water tubes should be mechanically cleaned to ensure optimum condenser efficiency. Frequency of cleaning will depend on individual water conditions, so a suitable cleaning schedule should be arranged based on experience and knowledge of the building or local water supply loop. Cleaning brushes are available from most refrigeration supply outlets. For better results, always remove both heads before cleaning water tubes.

Note that head gaskets do not require renewing at every maintenance operation. However, if the head gasket is physically disfigured or deteriorated in any way, the system will require new gaskets in order to retain the watertight seal required for correct system operation.

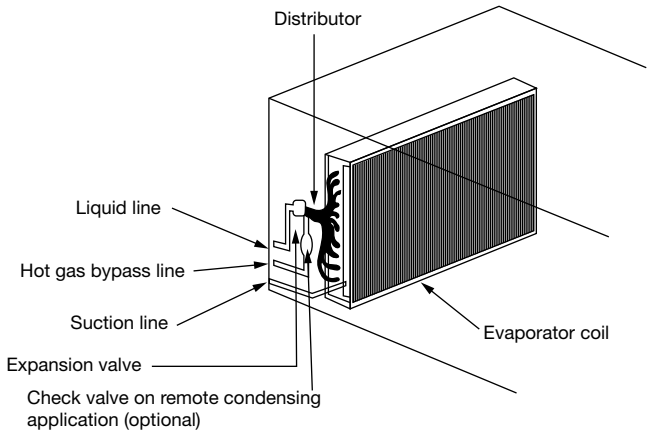
Evaporator Section

The direct expansion (DX) coil is constructed of seamless copper tubing expanded into full collared aluminum fins. The tubes are arranged for a counter-flow circuit and staggered to provide maximum heat transfer. A pressure type distributor with hot gas inlet port and a heavy duty copper suction header are included. Additional refrigerant circuit components include thermostatic expansion valves (TXV) with external equalizer and hot gas bypass valves on the full face of the leaving side of the direct expansion coil (HGBP option is removed when optional digital scroll compressors are utilized).

Components of a Direct Expansion System

The evaporator is that part of the low pressure side of the refrigerant system in which the liquid refrigerant boils or evaporates, absorbing heat as it changes into a vapor.

Figure 10: Direct expansion coil



⚠ WARNING

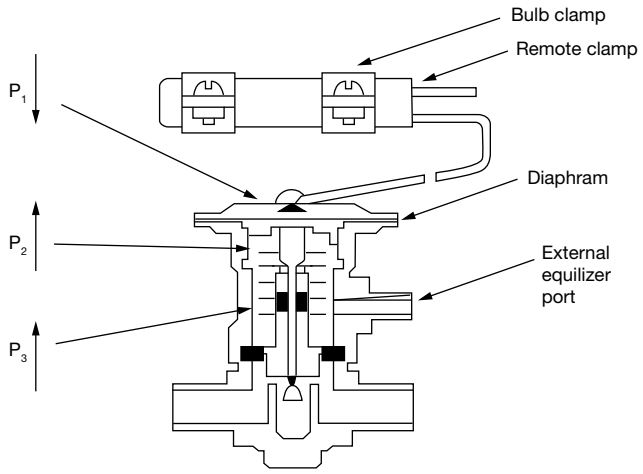
Many of the following steps need to be performed with the unit **powered off** and locked out. Disconnect the main power switch to the unit before performing service and maintenance procedures.

Thermostatic Expansion Valve

The thermostatic expansion valve is a precision device designed to meter the flow of refrigerant into the evaporator, thereby preventing the return of liquid refrigerant to the compressor. By being responsive to the temperature of the refrigerant gas leaving the evaporator and the pressure in the evaporator, the thermostatic expansion valve can control the refrigerant gas leaving the evaporator at a predetermined superheat. Three forces that govern the operation of the TXV are:

1. The pressure created by the remote bulb and power assembly (P1).
2. The evaporator pressure (P2).
3. The equivalent pressure of the superheat spring (P3).

Figure 11: Thermostatic expansion valve



Dampers

Units from Mammoth may or may not incorporate the use of dampers. If dampers are present within the unit, the following maintenance should occur in order to prevent the unit from working under too much pressure and to prevent any other issues.

Dampers must be kept free of foreign matter that might impede normal free movement. Bearings between blades and frames are made of polymer and require no maintenance. Note that the damper shafts do not need lubrication. All Mammoth dampers and linkages are assembled with non-lubricating bearings.

- Attachment mechanism linking motors to dampers should be checked for tightness.
- Damper jackshafts (if provided) are fitted with grease nipples and should be lubricated once a year. Use a premium quality lithium based grease conforming to NLGI Grade 2 or 3 (examples are: Mobil Mobilith AW2, Chevron Amolith #2, Texaco Premium RB or Shell Alvania #2).
- Dampers should be inspected for dirt; check the shaft, arms, bars and controls rod every three months.
- Inspect the seals to ensure none have pulled loose or deteriorated. If a seal has been damaged, repair or replace it with the same seal or same seal material. Contact the factory for replacement parts.

Belt Driven Fans

⚠ WARNING

Many of the following steps need to be performed with the unit **powered off** and locked out. Disconnect the main power switch to the unit before performing service and maintenance procedures.

Belt driven fan, motor and drive assemblies should be checked and inspected at regular intervals per the inspection list and procedures below. Listen for vibrations or unusual sounds. Severe damage, premature failure and loss of airflow can be avoided by regular inspection and maintenance.

1. Check the fan, motor and bearing mounting bolts for tightness according to the bolt torque chart in Table 1 below at time of start-up, after 24 hours, then every three months.

Table 1: Minimum Head Bolt Torque in lb-ft (Grade 5 Bolts)

Size (Inches)	Thread Designation	Minimum Torque
1/4–20	UNC	6
1/4–28	UNF	7
5/16–18	UNC	14
5/16–24	UNF	16
3/8–16	UNC	24
3/8–24	UNF	28
7/16–14	UNC	42
7/16–20	UNF	45
1/2–13	UNC	69
1/2–20	UNF	83
9/16–12	UNC	99
9/16–18	UNF	118
5/8–11	UNC	150
5/8–18	UNF	176
3/4–10	UNC	254
3/4–16	UNF	301
7/8–9	UNC	358
7/8–14	UNF	422
1–8	UNC	500
1–14	UNF	602

Soft metric conversions are not acceptable for screw and hex sizes.

2. Check the fan wheel hub, bearings and drive sheave set screws for tightness according to the set screw torque chart in Table 2 and Table 3 at time of start-up, after 24 hours of operation, monthly for the initial three months then every three months thereafter. If wheel or bearing set screws have worked loose, check the wheel for any signs of movement (inlet space clearance between the fan wheel and housing) or loose blades. If Loctite was used on any set screws that have come loose, the set screws must be removed and cleaned before re-tightening and Loctite must be re-applied.

Table 2: Wheel Set Screw Torque in lb-ft

Set Screw Size Diameter (Inches)	Carbon Steel Set Screw Torque*	
	lb-in	lb-ft
1/4	75	6.2
5/16	144	12.0
3/8	252	21.0
7/16	396	33.0
1/2	600	50.0
5/8	1,164	97.0
3/4	2,016	168.0
7/8	3,204	267.0
1	4,800	400.0

**Stainless steel set screws are not hardened and should not be tightened to more than half the values shown.*

Table 3: Bearing Set Screw Torque in lb-in

Set Screw Diameter	Manufacturer				
	Link Belt	Sealmaster	SKF	McGill	Dodge
#10	40	—	35	35	—
1/4	90	65	50	85	—
5/16	185	125	165	165	160
3/8	325	230	290	290	275
7/16	460	350	350	—	—
1/2	680	500	620	—	600
5/8	1,350	1,100	1,325	—	1,200
3/4	2,350	—	—	—	2,000

Split pillow block bearings are fixed to the shaft with tapered sleeves and generally do not have set screws.

3. Check each V-belt tension and adjust the motor base for correct amount according to the deflection outlined in the Measuring Belt Tension procedure below and in Appendix H for type of belt at time of start-up, daily for the first week until they should acquire their permanent set, then monthly. All belts should have approximately the same amount of deflection. Be aware of mismatched or worn belt sets. If a belt must be changed, ensure to change all belts on the same drive at the same time. Never replace just one belt within a set.

   Measuring Belt Tension

   a. Measure the belt span with a span scale.
   b. Divide the belt span by 64 to determine the belt deflection needed to check tension.
   c. Set the O-ring on the span scale to the required deflection value.
   d. Set the small O-ring at zero on the force scale.
   e. Place the scale end of the tension checker squarely on one belt at the center of the belt span. Apply force on the plunger until the bot-

> **⚠ WARNING**
>
> Many of the following steps need to be performed with the unit **powered off** and locked out. Disconnect the main power switch to the unit before performing service and maintenance procedures.

tom of the large O-ring is even with the top of the next belt or until it is even with a straight edge laid across the sheaves.

f. Read the force scale under the small O-ring to determine the force required to give the needed deflection.

g. Compare the force scale reading in Step F above with the correct value for the belt style and cross section. The force scale reading should be between the minimum and maximum values shown in Appendix H.

h. If the deflection value is below the minimum, tighten the belts. If the deflection value is above the maximum, loosen the belts. The tension on new belts should be checked during the first day of operation, at the end of the first week and monthly thereafter.

4. Check the fan and motor sheave alignment using a straight edge along the outside edges of the sheaves for equal sized fixed sheaves as shown in Figure 12 and Figure 13 at time of start-up, after 24 hours of operation, monthly for the initial three months, then every three months thereafter. When properly aligned, the straight edge should touch the full face of both sheaves. With one adjustable and one fixed sheave with unequal sizes, use a string placed at the center grove of both sheaves pulled tight to check alignment. Adjust sheaves for proper alignment and set screws to proper torque.

Figure 12: Equal sheave size alignment

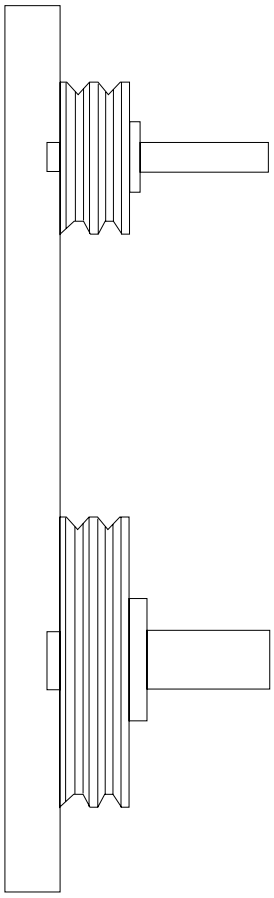
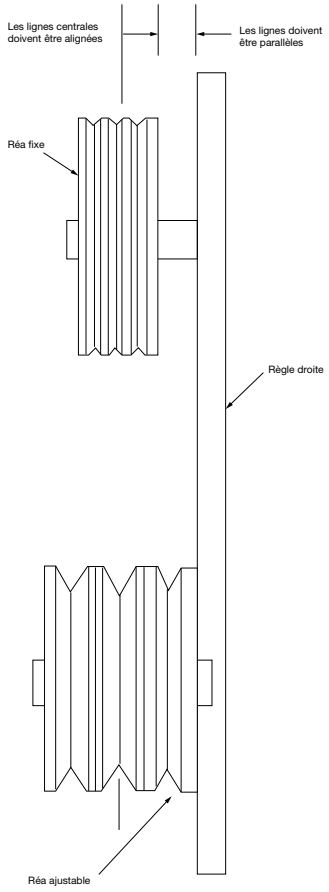


Figure 13: Unequal sheave size alignment



5. Belt driven fan bearings are fitted with grease nipples for lubrication. The grease quantity and lubrication interval depends on bearing (fan size) and rpm and are indicated in Table 4 and Table 5. Use a premium quality lithium based grease conforming to NLGI Grade 2 or 3 (examples are: Mobil Mobilith AW2, Chevron Amolith #2, Texaco Premium RB, Shell Alvania #2 or Esso Beacon #325). Clean the grease nipple first, then rotate the fan shaft slowly by hand while adding grease. The lubrication intervals are theoretical and will depend on site conditions, hours of operation and temperature. It is recommended to make periodic inspections of the bearings before these theoretical intervals.

⚠ WARNING

Many of the following steps need to be performed with the unit **powered off** and locked out. Disconnect the main power switch to the unit before performing service and maintenance procedures.

Table 4: Recommended Grease Quantity

Shaft Size		Maximum Grease Capacity of Bearing Chamber	
Inches	Millimeters	Ounces	Kilograms
0.500–0.750	13–19	0.125	0.004
0.875–1.187	25–31	0.375	0.011
1.250–1.500	32–38	0.625	0.018
1.687–1.937	43–49	0.875	0.025
2.000–2.437	51–62	1.250	0.035
2.500–2.937	63–75	2.000	0.056
3.000–3.437	76–87	3.500	0.098
3.500–4.000	89–102	6.000	0.168
4.187–4.937	106–125	10.000	0.280

6. Fan, wheels, housings and drive assemblies should be checked for dirt buildup annually and cleaned if necessary to keep them from becoming unbalanced and to prevent loss of airflow. Clean with compressed air to reduce any dirt, dust, lint or larger particulates that have bonded to the fan impeller housing or drive assembly. Block dirt from entering the unit and ductwork if necessary or remove fan assembly from unit. Alternatively use low pressure steam, a degreaser and rag. If a sheave requires cleaning, detergent and water can also be used. Ensure the belt is dry before starting up the unit.

IMPORTANT

Be careful not to remove or dislodge balancing clips on the fan blades while cleaning.

Table 5: Generally Recommended Relubrication Frequency in Months

Operating Speed (RPM)	0.500–1.000" [13–35 mm]	1.125–1.500" [28–38 mm]	1.625–1.937" [41–49 mm]	2.000–2.500" [50–63 mm]	2.687–3.187" [68–81 mm]	3.437–3.937" [87–100 mm]
up to 500	6	6	6	6	5	4
500–1,000	6	6	6	5	4	3
1,000–1,500	5	5	5	4	3	3
1,500–2,000	5	4	4	3	2	1
2,000–2,500	4	4	3	2	1	—
2,500–3,000	4	3	2	1	2	—
3,000–3,500	3	2	2	2	—	—
3,500–4,000	3	2	1	—	—	—
4,000–4,500	2	1	1	—	—	—
4,500–5,000	2	1	—	—	—	—

⚠ WARNING

Many of the following steps need to be performed with the unit **powered off** and locked out. Disconnect the main power switch to the unit before performing service and maintenance procedures.

Maintenance Schedule

FANWALL array of multiple direct driven plenum fan and motor "cubes" are equipped with permanently sealed bearings and do not require lubrication. The following maintenance schedule is recommended.

1. Monthly
   a. Check the fan wheel to inlet cone alignment for possible noise from the wheel rubbing against the inlet cone. See Fan Wheel/Cone Alignment below for instructions.
2. Every six months
   a. Check motor bearings for possible binding noise or overheating.
   b. Check fan wheels for dirt and grease accumulation. Clean as necessary. Do not use any caustic cleaning solutions.
3. Annually
   a. Lightly lubricate damper and linkage bushings on backdraft dampers (if equipped).
4. Every two years
   a. Examine fan housings and motor pedestal for corrosion. Clean and touch up with paint as necessary.

Figure 14: FANWALL array

Fan Wheel and Motor Removal

1. Disconnect power to the fan array control panel before maintenance. Follow all lockout and tag out procedures.
2. Remove the optional safety screen (if provided) on the motor end only of the cube in question by removing all four hex screws from the holding flange that retains the safety screen (see Figure 15).

Figure 15: Remove safety screen on motor end

3. Disconnect the four-wire electrical cable from the motor junction box. Make note of wire locations for reinstallation later (see Figure 16).

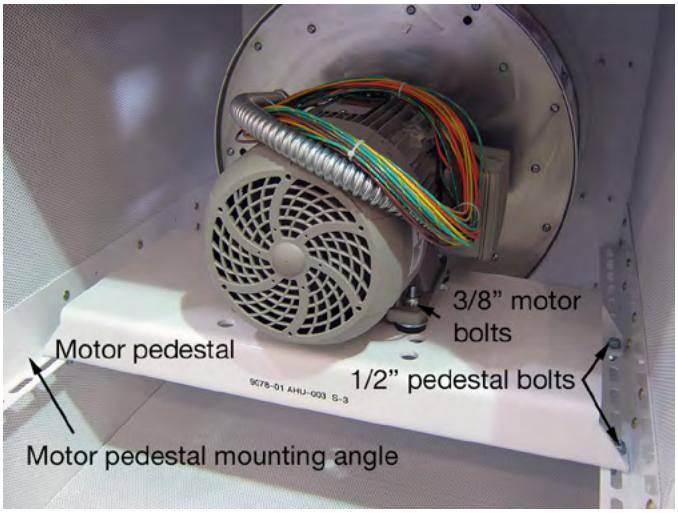
Figure 16: Remove electrical cable

⚠ WARNING

Many of the following steps need to be performed with the unit **powered off** and locked out. Disconnect the main power switch to the unit before performing service and maintenance procedures.

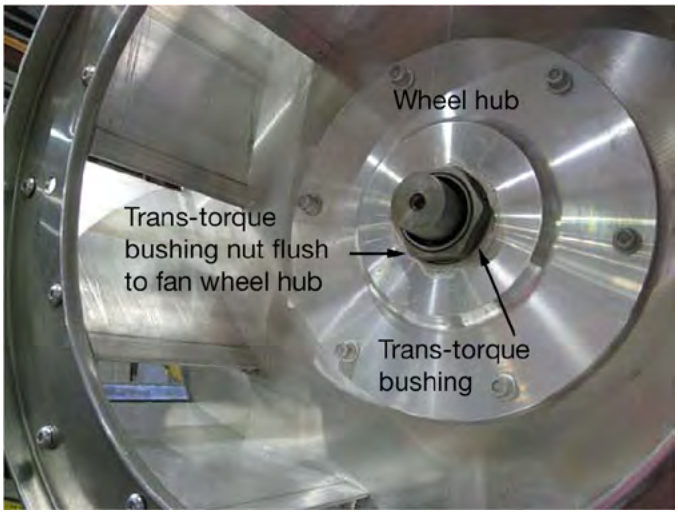
4. Mark motor pedestal location on the motor pedestal mounting angles (both sides), then loosen and remove (four) ½" bolts that retain the motor pedestal to the mounting angles (see Figure 17).

Figure 17: Remove motor pedestal retaining bolts



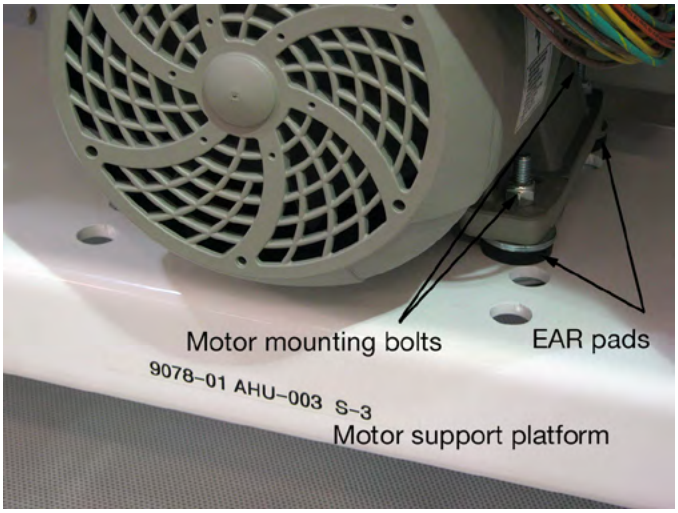
5. After removing the motor pedestal retaining bolts, slide the motor/fan/pedestal assembly out to the point where the motor lifting ring is clear of the cube frame enough to use. If a mechanical device is available for use, attach it to the motor lifting ring. Lift and remove the motor pedestal with motor and fan wheel from the cube. The motor pedestal with motor and fan wheel can be turned 180º and slid back into the cube on the pedestal mounting angles or removed from unit for further disassembly.
6. Mark the location of the trans-torque bushing on the shaft and the fan. To remove the fan wheel from the motor shaft, remove the trans-torque bushing retaining hex nut using a 1" socket with a 12" extension by turning counter-clockwise. Loosen progressively until the bushing is free from wheel hub and motor shaft. Remove fan wheel/hub assembly (see Figure 18).

Figure 18: Mark location and remove trans-torque bushing and fan wheel from motor.



7. If needed, the motor may now be removed for service by removing all (four) 3/8" motor retaining nuts and bolts. Be sure to mark the motor base pattern and bolt holes used on the motor pedestal. Rubber isolator pads between the motor base and the pedestal are optional and if supplied be sure not to lose them (see Figure 19).

Figure 19: Remove motor retaining bolts; do not lose rubber isolator pads (if provided).

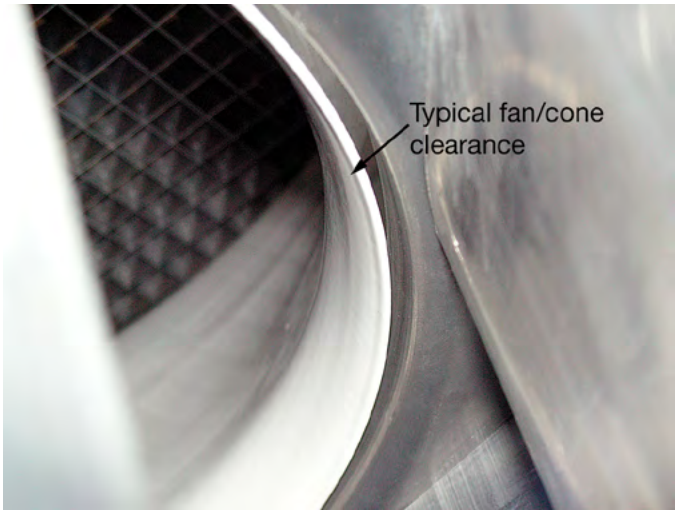


⚠ WARNING

Many of the following steps need to be performed with the unit **powered off** and locked out. Disconnect the main power switch to the unit before performing service and maintenance procedures.

8. To re-install the motor, fan wheel and fan wheel/motor/pedestal assembly back into the cube, reverse the steps above noting the following:
   a. Insert the (four) 3/8" motor retaining bolts into the holes in the motor pedestal from the underside, make sure to use a standard washer on the bolt side, install the rubber isolator pads (if supplied) between the pedestal and motor base and only a locknut is required on the motor side.
   b. Square the motor on the pedestal according to markings and tighten the bolts. With rubber isolator pads tighten the bolts to 20 ft-lbs. Without rubber isolator pads tighten the bolts to 40 ft-lbs.
   c. Install the fan wheel on the motor shaft with the hub facing towards you. Line up the markings on the hub/trans-torque bushing/shaft. Make sure that the trans-torque bushing nut is flush to the hub. Tighten the bushing nut progressively to 80 ft-lbs turning clockwise.
9. Lift the motor pedestal with motor and fan wheel (turn 180º if placed on the pedestal mounting angles for disassembly) with the fan wheel inlet toward the inlet cone. Place motor pedestal into the cube on the pedestal mounting angles and slide the pedestal forward to the line that you previously marked. Line the four pedestal bolt holes up with the bolt holes on the mounting angles. Insert (four) ½" bolts into the holes, make sure to use a standard washer on the bolt side and a standard washer and lock washer on the nut side. Hand tighten the bolts for now.
10. Check the inlet cone alignment to the fan wheel. Fan wheel should not be rubbing against the fan inlet cone when rotated by hand. The fan wheel to inlet cone clearance should be approximately 1/16" gap and the overlap should be as indicated in Appendix I for the fan wheel size. Adjust the overlap of the wheel and cone by moving the motor pedestal forward or backward. Fan wheel should not be rubbing on the inlet cone. If cone alignment is required see instructions for Fan Wheel/Cone Alignment below. Once alignment and overlap are correct tighten the (four) ½" pedestal mounting bolts to 90 ft-lbs.

Figure 20: Check fan wheel/cone alignment and overlap.



11. Reconnect the four-wire electrical cable from the motor junction box. Before operation, start the motor slowly to ensure the fan rotation is correct. If the fan wheel is not rotating correctly, check the motor leads for proper installation.
    a. *Drive Side* – Clockwise rotation when looking at motor end.
    b. *Inlet Side* – Counter-clockwise rotation looking at fan inlet.

IMPORTANT

Before re-starting, re-balance the fan wheel once the motor rotation and alignment have been corrected before placing the unit in operation.

⚠ WARNING

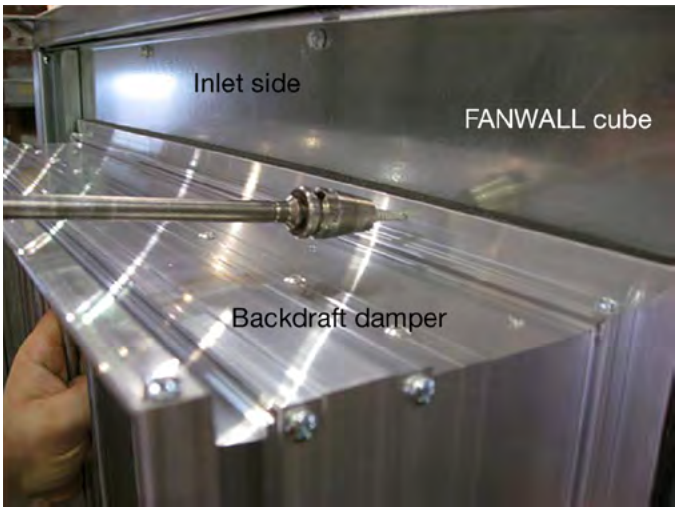
Many of the following steps need to be performed with the unit **powered off** and locked out. Disconnect the main power switch to the unit before performing service and maintenance procedures.

Fan Wheel/Cone Alignment

1. To align fan wheel/cone, first disconnect power to the fan array control panel. Follow all lockout and tag out procedures.
2. If the optional backdraft damper is furnished on the inlet side of the fan it must be removed first. Remove all tek screws on all sides attaching the damper frame to the inlet side panel and remove it from the cube. The purpose of the damper is so that maintenance staff can block the intake of a single fan to prevent back flow until service on an inoperative assembly can be performed. Note the directions of the damper blades are running vertical. The damper is installed directly onto the FANWALL® cube inlet side panel and over the optional airflow straightener (if supplied).

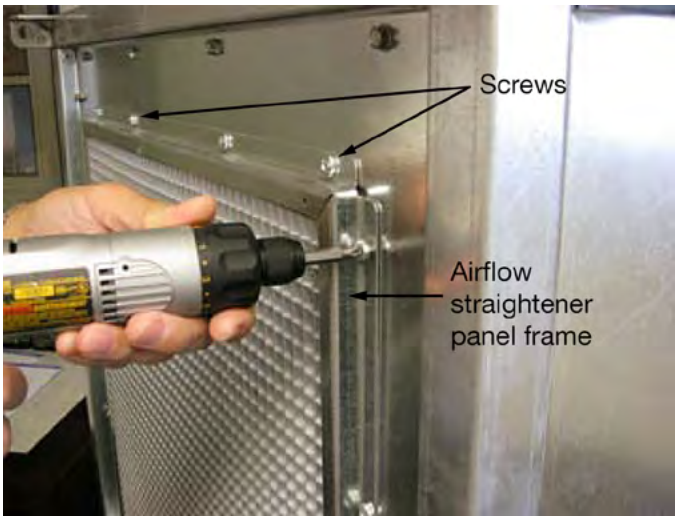
Figure 21: Fan wheel/cone alignment – Step 2a

Figure 22: Fan wheel/cone alignment – Step 2b



3. If the optional airflow straighteners are furnished on the inlet side of the fan it must be removed next. Remove all tek screws on the airflow straightener panel frame and remove it from the cube.

Figure 23: Fan wheel/cone alignment – Step 3



⚠ WARNING

Many of the following steps need to be performed with the unit **powered off** and locked out. Disconnect the main power switch to the unit before performing service and maintenance procedures.

4. Gently rotate the fan wheel to verify location of adjustment required.

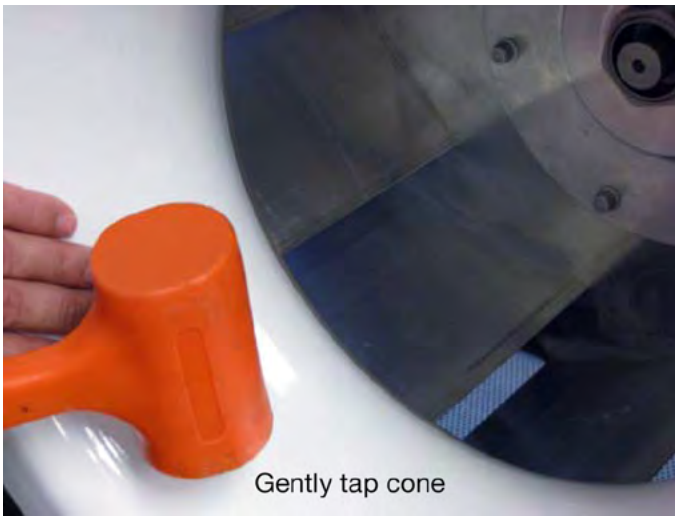
Figure 24: Fan wheel/cone alignment – Step 4

5. To make adjustment, loosen (do not remove) all the cone retaining fasteners.

Figure 25: Fan wheel/cone alignment – Step 5

6. Using a rubber mallet, gently tap around the cone until desired clearance is acquired between fan wheel and inlet cone.

Figure 26: Fan wheel/cone alignment – Step 6



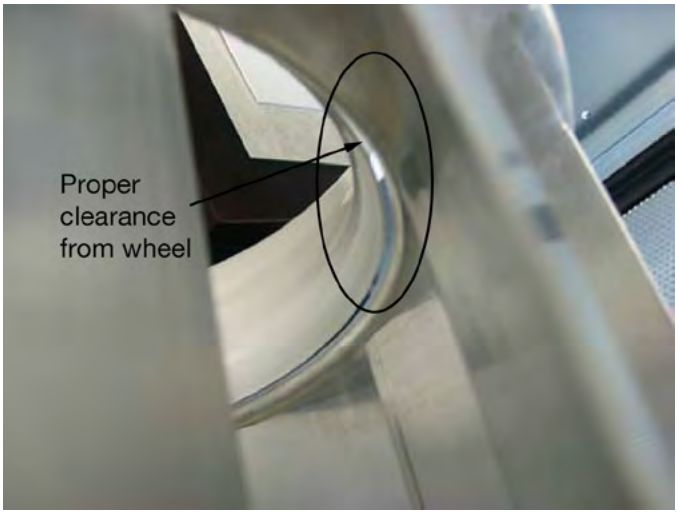
7. Gently rotate the fan wheel to verify cone adjustment for proper clearance from wheel.

Figure 27: Fan wheel/cone alignment – Step 7a and Step 9a

⚠ WARNING

Many of the following steps need to be performed with the unit **powered off** and locked out. Disconnect the main power switch to the unit before performing service and maintenance procedures.

Figure 28: Fan wheel/cone alignment – Step 7b and Step 9b



8. Tighten all the cone retaining fasteners.

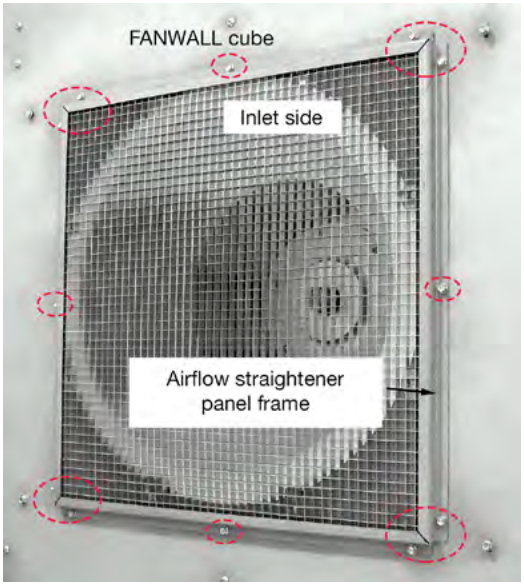
Figure 29: Fan wheel/cone alignment – Step 8

9. Once again gently rotate the fan wheel to verify cone alignment.
10. To install the optional airflow straightener or back-draft damper reverse the steps above.

Blank-off Plate (If Applicable)

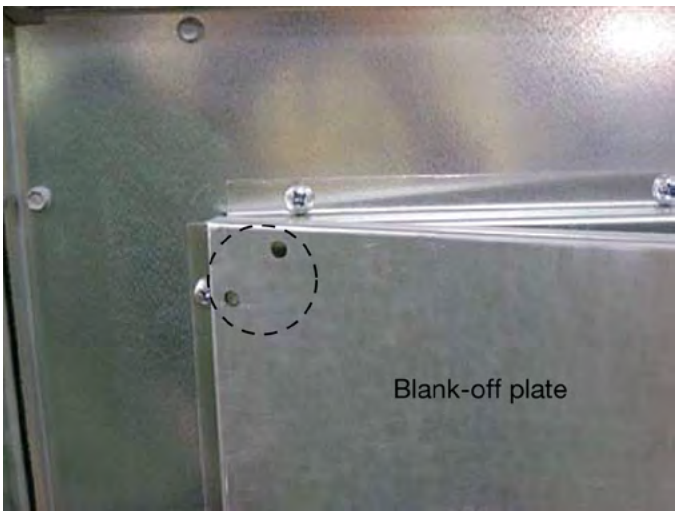
1. Optional blank-off plate(s) are available so that maintenance staff can block the intake of a single fan to prevent back flow until service on an inoperative assembly can be performed or it can be mounted on spare FANWALL® cube(s) until they are required to be put into service.
2. First disconnect power to the fan array control panel. Follow all lockout and tag out procedures.
3. The blank-off plate is fitted to the inlet side of the FANWALL cube on the optional airflow straightener panel frame (if supplied) or onto a matching "Z" frame. There are 12 pre-drilled holes which are located in the corners and middle of the airflow straightener panel frame or "Z" frame matching pre-drilled holes in the blank-off plate for fastening together with tek screws.

Figure 30: Blank-off plate – Step 3



4. Place the blank-off plate over the optional airflow straightener panel frame (if supplied) or onto the matching "Z" frame and pre-drilled holes and fasten together with or remove tek screws.

Figure 31: Blank-off plate – Step 4



Motors

> **⚠ WARNING**
> Many of the following steps need to be performed with the unit **powered off** and locked out. Disconnect the main power switch to the unit before performing service and maintenance procedures.

Motors will operate effectively for years if they are kept clean, dry and properly lubricated. An excessive running current is a good indication of the overall condition of the motor. Check the following items every six months (unless otherwise indicated) for proper performance:

- Motors must be cleaned with moderate air pressure (around 25 to 30 psi). Dirt must be blown away from vent fins and all other accessible areas. All areas surrounding the motor must be kept clear so air can circulate freely to cool the motor.
- Ensure all connections are secure. Look for loose wires and loose contacts. Repair and tighten any defective connection.
- Ensure the motor is operating at the current indicated on the nameplate. If not, a physical or electrical restriction is working against the motor and it must be repaired.
- Ensure the motor is not vibrating too much. A significant vibration can come from a loose mounting bolt or an unbalanced impeller. If significant vibration has occurred, be sure to repair it and inspect the mounting base and the flexible duct connection for any damage.
- Motor lubrication must occur once a year when grease nipples are provided with a premium quality lithium based grease conforming to NLGI Grade 2 or 3 (examples are Mobil Mobilith AW2, Chevron Amolith#2, Texaco Premium RB, Shell Alvania #2 or Esso Beacon #325). Clean the grease nipple first, then rotate the motor shaft slowly by hand while adding grease with a low pressure grease gun. **Do not over lubricate!**

Filters

Standard 2” [51 mm] and 4” [102 mm] prefilters are disposable and should be replaced every three months or sooner if the pressure drop across the filters is too great. High efficiency filters (optional) should be replaced when dirty. Mammoth recommends that they be used only in combination with 2” [51 mm] or 4” [102 mm] prefilters in order to protect them from premature clogging and to increase their effective lifespan. The tables in Appendix J provide data relative to the pressure drop across clean filters and indicate the type of reading that should be given on the magnehelic gauge. The data relative to accurate pressure drop across the filters is available in the submittal. If the system is equipped with both prefilters and final filters, it is recommended that prefilters be changed twice as often as final filters. Running a unit with dirty and inefficient filters will lower the airflow and thus lower the air quality of the area.

Coils

⚠ WARNING

Many of the following steps need to be performed with the unit **powered off** and locked out. Disconnect the main power switch to the unit before performing service and maintenance procedures.

Dirt on the surface of the coil reduces its ability to transfer heat which lowers the efficiency of the unit, resulting in poor air quality and expensive operating costs. Because of the condensate on the coil, the dirt often becomes wet and contributes to the growth of microbial organisms. Negligence in maintenance may result in serious health related indoor air quality problems. The coil should be kept clean for maximum performance. To achieve maximum efficiency, clean the coil often during periods of high demand or when dirty conditions prevail. Mammoth recommends cleaning the coil a minimum of once per year to prevent dirt buildup in the coil fins where it may not be visible.

CAUTION

Do not use acidic chemical coil cleaners. Do not use alkaline chemical coil cleaners with a pH value greater than 8.5 or lower than 6 (after mixing) without using an aluminum corrosion inhibitor in the cleaning solution. Using these types of cleaners may result in unit damage.

Coil fins can be cleaned by using steam with detergent, hot water spray or a commercial chemical coil cleaner. After cleaning the coil, be sure to rinse thoroughly.

Cleaning Procedure

1. Shut down the unit by closing the main disconnect at the power inlet.
2. Open panels or doors to gain access to both sides of the coil section.
3. Remove soft debris from both sides of the coil with a soft brush.
4. Using a steam cleaning machine, clean the leaving air side of the coil first (going downward) then clean the entering air side. Use a block-off to prevent the steam from penetrating a dry section of the unit.
5. Allow the unit to dry thoroughly before restoring power.
6. Damaged coil fins should be straightened by using a fin comb.
7. Close all panels and doors once the coil is dry.
8. Restore electrical power to the unit.

Controls

General controls information regarding the navigation and monitoring of your unit with the standard keypad, DDC points list, ladder diagram and specific sequence of operation or required network communication is included in the documentation that is contained in the control panel of your unit. Please contact the factory if this information is missing or has been lost.

Troubleshooting

See Appendix K for troubleshooting information. For troubleshooting information on WCC, compressors and refrigeration circuits, see Appendix A.

Appendix A: Water Cooled Condenser (WCC) Piping Installation, Maintenance and Troubleshooting

Units have the WCC supply and return line internally coupled (manifold) and piped to the unit exterior. The WCC connections shall have copper IPS connections. See the submittal drawings for size, location, flow rate, type of fluid, pressure drop information and components included and factory installed for the supply and return connections.

Optional Water Piping Components

The following components may or may not be included and factory installed depending on the water conditions and/or options selected.

1. A two-way or three-way modulating head pressure control valve may be included in the compressor or coil compartment to maintain stable operation of the refrigeration systems when operated on ground loop or cooler water systems when the design inlet water temperature is below 70°F in the cooling mode. A refrigerant pressure transducer is also included and factory installed in the compressor compartment on the compressor discharge, which will modulate the water flow to the condenser using a 2 to 10 VDC signal to prevent the compressor discharge pressure from falling below the compressor operating limit. The regulating valve may be factory installed or shipped loose for field installation depending on the unit configuration and/or options selected
2. A flow switch on the water return or leaving side of the condenser is factory provided and installed in the compressor or coil compartment to monitor the presence or absence of flow, which will shut down the compressor operation if no flow is detected.
3. A water temperature sensor on the water supply or entering side of the condenser is factory provided and installed in the compressor or coil compartment to monitor the water temperature, which will shut down/disable the compressors if the entering water temperature drops below 70°F. For units with waterside economizer (WiSE) coils, the entering water temperature sensor shall be utilized to compare the unit entering water temperature to the unit entering air temperature and enable WiSE operation when applicable.
4. A waterside economizer coil along with dual two-way modulating water economizer valves and a temperature sensor shall be supplied with the unit. The water temperature sensor is input to the DDC control system, which determines when to divert water to the economizer coil for energy conservation in cooling mode.

Water Piping Components Not Included

Water piping vibration eliminators, manual or automatic shut-off valves, pressure and temperature gauges, water strainer, vent valves or air vents, flow measuring and balancing valves, pressure relief valves or other safety or control piping requirements are not available and must be field provided and installed outside of the unit.

IMPORTANT

WCC external water supply and return piping shall be in accordance with National and Local Codes. Line sizing, pressure limiting devices, back flow preventers, strainers, valves, flow temperature and pressure measuring, freeze protection, all other safety or control piping requirements for system operation are the sole responsibility of the Installing Contractor and/or Design Engineer. The water supply must be sized for the maximum flow as indicated on the submittals.

Recommended Piping, Components and Installation

Recommended and required WCC water line piping and components with a detailed functional description are outlined below:

1. All WCC should be connected to supply and return piping in a two-pipe reverse return configuration. A reverse return system is inherently self-balancing and requires only trim balancing where multiple quantities of heat pumps with different flow and pressure drop characteristics exist in the same loop.
2. The water line piping may be steel, copper or PVC. Avoid dissimilar metal fittings as they may corrode. The piping should be installed with a minimum number of bends and elevation changes for best performances. Size piping to minimize system pressure drop.
3. Water line piping should contain:
   a. Short sections of high pressure flexible hose or vibration eliminators to reduce vibration and noise transmission. One end of the hose should have a swivel fitting to facilitate removal for service. Hard piping connections are not recommended due to the possibility of vibration that could damage piping connections, joints or transmit noise. Where hard piping is used, unions should be provided in the supply and return lines for service and removal.
   b. Manual shut-off valves in supply and return water lines for isolation and service.

c. Pressure and temperature gauge connections in the supply and return water lines to aid in start-up and service.
d. A water strainer (16–20 mesh minimum) or some means of removing foreign matter from the water.
e. Manual vent valves and/or automatic air vents at the high points of the system in the supply and return water lines to discharge non-condensable air in order to avoid unexpected high head pressure and poor cooling/heating performance.
f. A flow balancing valve in the return water line to set the required flow rate.
g. A flow measuring valve or pressure gauge/connections in the return water line to measure the required flow rate.
h. A two-way motorized on/off water shut-off valve to isolate water flowing through both the economizer coil (if equipped) and water-to-refrigerant condenser for conservation when the unit is off. The motorized water valve must open 90 seconds prior to compressor start-up and remain open five seconds after the compressor is shut off.
i. A relief valve in the water supply or inlet line if the maximum pressure of components is less than the water supply pressure to prevent damage, injury or death due to instantaneous release of high pressure water.

⚠ WARNING

To prevent injury or death due to instantaneous release of high pressure water, provide relief valves on system water piping. This will also help prevent water pump damage or stoppage due to excessive system pressure.

4. WCC should not be connected to the incoming supply and return piping until the water supply system has been cleaned and flushed completely. After the cleaning and flushing has taken place, the initial connection should have all valves wide open in preparation for the water system flushing.
5. Automatic flow controlled devices must not be installed prior to system cleaning and flushing.

Cleaning and Flushing

1. Prior to first operation of the WCC, the water circulation system must be cleaned and flushed of all construction dirt and debris by the Installing Contractor.
2. Short circuit connect the incoming supply line to the outgoing return line, prior to the factory installed piping at each connection point, before flushing to prevent the introduction of dirt into the unit from the supply line completed on site. This will prevent the introduction of dirt into the unit.
3. Fill the system at the city water makeup connection with all air vents open. After filling, close all air vents.
4. Start the main circulator with the pressure reducing valve open. Check vents in sequence to bleed off any trapped air to provide circulation through all components of the system.
5. While circulating water, check and repair any leaks in the piping. Drains at the lowest point(s) in the system should be opened for the initial flush and blow down, making sure city water fill valves are set to makeup water at the same rate. Check the pressure gauge at the pump suction and manually adjust the makeup to hold the same positive steady pressure both before and after opening the drain valves. Flush should continue for at least two hours or longer until clean drain water is visible.
6. Shut off the circulator pump and open all drains and vents to completely drain down the system. Short circuited supply and return lines coming to the unit should now be removed and supply and return lines connected to the unit supply and return connections. Do not use sealers at the swivel flare connections of the hose(s).
7. Install any automatic flow controlled devices that were removed for flushing.
8. Refill the system with clean water. Test the water using litmus paper for acidity, and treat as required to leave the water slightly alkaline (pH 7.5 to 8.5). The specified percentage of antifreeze may also be added at this time. Use commercial grade antifreeze designed for HVAC systems only. Do not use automotive grade antifreeze.
9. Once the system has been filled with clean water and antifreeze (if used), precaution should be taken to protect the system for dirty water conditions. Dirty water will result in system wide degradation of performance and solids may clog valves, strainers, flow regulators, etc. Additionally, the heat exchangers may become clogged which reduces compressor service life or causes premature failure.
10. Start the circulation pumps. After full flow has been established through all components, air vented, lines checked for leaks and loop temperatures stabilized, the WCC will be ready for check, start-up and water balancing.

General Maintenance

Recording of performance measurements of volts, amps, and water temperature difference (both heating and cooling) is recommended. A comparison of logged data with start-up and other annual data is useful as an indicator of general equipment condition.

Periodic lockouts almost always are caused by air or water problems. The lockout (shut-down) of the unit is a normal protective result. Check for dirt in the water system, water flow rates, water temperatures, airflow rates (may be dirty filters), and air temperatures. If the lockout occurs in the morning following a return from the night setback, entering air below machine limits may be the cause.

Water treatment is important for proper condenser operation. Proper water treatment is essential to prevent galvanic corrosion from occurring in the condenser/water system. The proper use of corrosion inhibitors and maintaining proper pH levels are critical elements. The use of sacrificial anodes can also be beneficial in certain water applications. Improper water treatment will lead to equipment performance/corrosion problems and will require frequent equipment cleaning/servicing. For project/site specific water treatment instruction, consult your local water treatment specialist.

Monthly

- Check water cooled condensers for scaling and proceed with brushing and cleansing if necessary.

Quarterly

- Check oil level in compressor (half site glass).

Semi-annually

- Check operation of crank case heaters.
- Check for broken or loose pipe clamps.
- Check moisture indicator of refrigerant site glass. A “Caution” or “Wet” condition requires changing filter drier. If “Wet” condition does not improve, it will be necessary to evacuate system.

Yearly

- Look for any sign of oil on all refrigeration components including coils, compressors, controls, tubing, etc. Oil would indicate a refrigerant leak.
- Check water lines for leaks.
- Check expansion valve bulb (properly attached to suction line, properly isolated).
- Check the condensate drain pan and clean and flush as required.

Troubleshooting

Lubrication

R410a should be used only with polyolester (POE) oil. The HFC refrigerant components in R410a will not be compatible with mineral oil or alkylbenzene lubricants. R410a systems will be charged with the OEM recommended lubricant, ready for use with R410a.

Charging

Due to the zeotropic nature of R410a, it should be charged as a liquid. In situations where vapor is normally charged into a system, a valve should be installed in the charging line to flash the liquid to vapor while charging.

CAUTION

It is very important to make certain that the recycle or recovery equipment used is designed for R410a. The pressure of R410a refrigerant is approximately 60% greater than that of R22. Pressure gauges require a range up to 800 psig high side and 250 psig low side. Recovery cylinders require a 400 psig rating.

IMPORTANT

Filter driers must be replaced each time a system is open to atmosphere (ex.: for a defective component replacement, refrigerant leak, etc.).

Compressor Burnout

When a motor burnout occurs in a compressor, the resulting high temperature arc causes a portion of the refrigerant/oil mixture to break down into carbonaceous sludge, corrosive acid and water. Such contamination resulting from a burnout can result in repeat failures if the contaminants are allowed to reach and remain in the crank case of the replacement compressor. This situation can be prevented by following proper cleanup procedures after a burnout.

To determine if a compressor burnout has actually occurred, run the proper electrical tests. This requires an accurate VOM Meter.

1. With all wires removed from the compressor terminals, measure resistance from each terminal to the compressor casing. If any terminal shows a direct ground (zero resistance), a failure has occurred. If not, continue.
2. With all wires removed from the compressor terminals, measure resistance from each compressor terminal. They should read the same. If two or more terminals show zero resistance between them, the compressor motor has failed (for actual resistance value, refer to the respective compressor manual or contact the Customer Service Department at Nortek Air Solutions Canada).
3. If steps 1 and 2 have not clearly identified a compressor failure, it will be necessary to meg the compressor motor (refer to the respective compressor manual or contact the Customer Service Department at Nortek Air Solutions Canada).

Compressor Burnout – System Cleanup

Any maintenance requiring refrigerant evacuation must be performed using proper recovery procedures.

1. In order to avoid losing refrigerant to the atmosphere, recover refrigerant using standard recovery procedures and equipment. Remove the inoperative compressor, and install the replacement.
2. Since the normal color of refrigerant oil varies from oil to oil, take a sample of oil from the replacement compressor and seal in a small glass bottle for comparison purposes after the cleaning operation is complete. Suitable two ounce bottles are available at any drug store.

⚠ WARNING

Acid burns to the skin can result from touching the sludge in the burned out compressor. Rubber gloves should be worn when handling contaminated parts.

3. Inspect all system controls such as expansion valves, solenoid valves, check valves, reversing valves, contactors, etc. Clean or replace if necessary, remove all installed filter driers.

IMPORTANT

Before starting the new compressor, replace any questionable components.

4. Install the recommended size suction line filter drier and new size liquid line filter drier. Evacuate system using the triple evacuation method. Re-charge the system with new refrigerant (do not use the recovered refrigerant). See unit's nameplate for proper refrigerant charge.
5. Start the compressor and put the system in operation. As the contaminants in the system are filtered out, the pressure drop across the suction line filter drier will increase. Observe the differential across the filter drier for a minimum of two hours. If the pressure drop exceeds the maximum limits for a temporary installation, replace the filter drier and re-start the system (see literature from filter drier's Manufacturer for pressure drop maximum limits.)
6. After the completion of Step 5, allow the unit to operate for 48 hours. Check the odor (warning – smell cautiously) and compare the color of the oil with the sample taken in Step 2. Use of an Acid Test Kit is recommended to test for acid content. If the oil is discolored, has an acid odor, is acidic or if the moisture indicator indicates a high moisture content in the system, change the filter driers. The compressor oil can be changed if considered desirable. Allow the system to operate for an additional four hours, and recheck as before. Repeat until the oil remains clean, odor and acid free and the color approaches that of the original sample.
7. Replace the liquid line filter drier with one of the normally recommended size. Remove the suction line filter drier.
8. After the cleaning procedure is completed, recheck in approximately two weeks to ensure that the system condition and operation is completely satisfactory.

Table A1: Troubleshooting Refrigeration Circuit

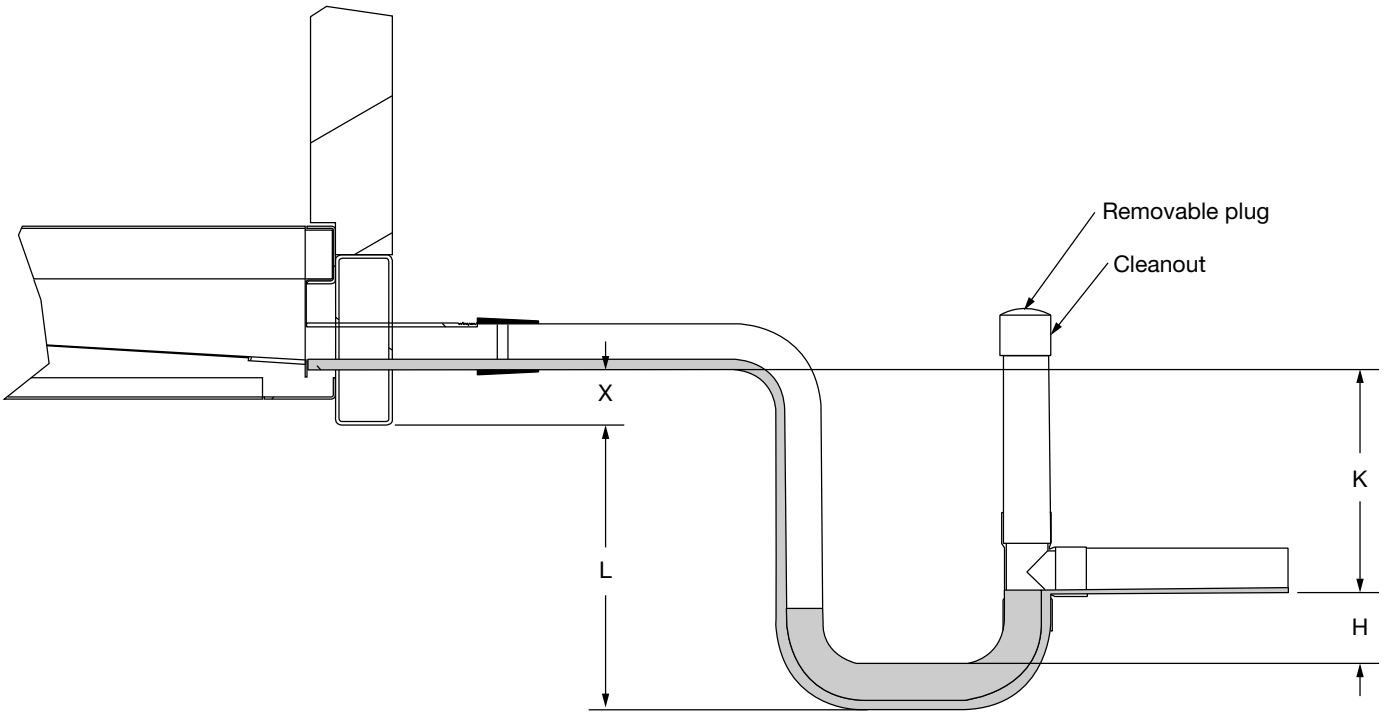
Symptom	Head Pressure	Suction Pressure	Compressor Amp Draw	Superheat	Sub-cooling	Air Temperature Differential	Water (Loops) Temperature Differential	Safety Lockout
Undercharged system (possible leak)	Low	Low	Low	High	Low	Low	Low	Low pressure
Overcharged system	High	High	High	Normal	High	Normal / Low	Normal	High pressure
Low airflow heating	High	High	High	High / Normal	Low	High	Low	High pressure
Low airflow cooling	Low	Low	Low	Low / Normal	Low	Low	Low	Low temperature
Low water flow heating	Low / Normal	Low / Normal	Low	Low	High	Low	High	Low temperature
Low water flow cooling	High	High	High	High	Low	Low	High	High pressure
High airflow heating	Low	Low	Low	Low	High	Low	Low	Low temperature
High airflow cooling	Low	High	Normal	High	Low	Low	Normal	High pressure
High water flow heating	Normal	Low	Low	Low	Normal	Normal	Low	High pressure
High water flow cooling	Low	Low	Low	Low	High	Normal	Low	Low temperature
TXV restricted	High	Low	Normal / Low	High	High	Low	Low	

Table A2: Performance Troubleshooting

Performance Troubleshooting	Heating	Cooling	Possible Cause	Solution
Insufficient capacity.	x	x	Dirty filter.	Replace or clean.
Not cooling or heating properly.	x		Reduced or no airflow.	Check for dirty air filter and clean or replace. Check fan motor operation and airflow restriction. Too high of external static. Check static vs. blower performance curve.
		x	Reduced or no airflow.	Check for dirty air filter and clean or replace. Check fan motor operation and airflow restriction. Too high of external static. Check static vs. blower performance curve.
	x	x	Leaky ductwork.	Check supply and return air temperature at the unit and at the distant duct registers. If significantly different, duct leaks are present.
Unit does not operate in cooling.	x	x	Low refrigerant charge.	Check superheat and sub-cooling; adjust charge.
	x	x	Restricted metering device.	Check superheat and sub-cooling; replace TXV.
		x	Defective reversing valve.	Perform reversing valve touch test.
	x	x	Unit undersized.	Re-check loads and sizing.
	x	x	Scaling in waterside heat exchanger.	Perform scaling check and clean if necessary.
	x	x	Inlet water too hot or too cold.	Check load, loop sizing, loop backfill, ground moisture.
High head pressure.	x		Reduced or no airflow.	Check for dirty air filter and clean or replace. Check fan motor operation and airflow restriction. Too high of external static. Check static vs. blower performance curve.
		x	Reduced or no water flow.	Check pump operation or valve operation/setting. Check water flow. Adjust to proper flow rate.
		x	Inlet water too hot.	Check load, loop sizing, loop backfill, ground moisture.
	x		Air temperature out of range.	Bring return air temperature within design parameters.
		x	Scaling in waterside heat exchanger.	Perform scaling check and clean if necessary.
	x	x	Unit overcharged.	Check superheat and sub-cooling.
	x	x	Non-condensable in system.	Vacuum system, re-weigh in charge.
Low suction pressure.	x		Reduced water flow.	Check pump operation or valve operation/setting. Check water flow. Adjust to proper flow rate.
	x		Water temperature out of range.	Bring water temperature within design parameters.
		x	Reduced airflow in cooling.	Check for dirty air filter and clean or replace. Check fan motor operation and airflow restriction. Too high of external static. Check static vs. blower performance curve.
		x	Air temperature out of range.	Bring entering air temperature within design parameters.
	x	x	Insufficient charge.	Check for refrigerant leaks.
Low discharge air temperature in heating.	x		Too high of airflow.	Check fan's motor speed selection and airflow.
	x		Poor performance.	See insufficient capacity.

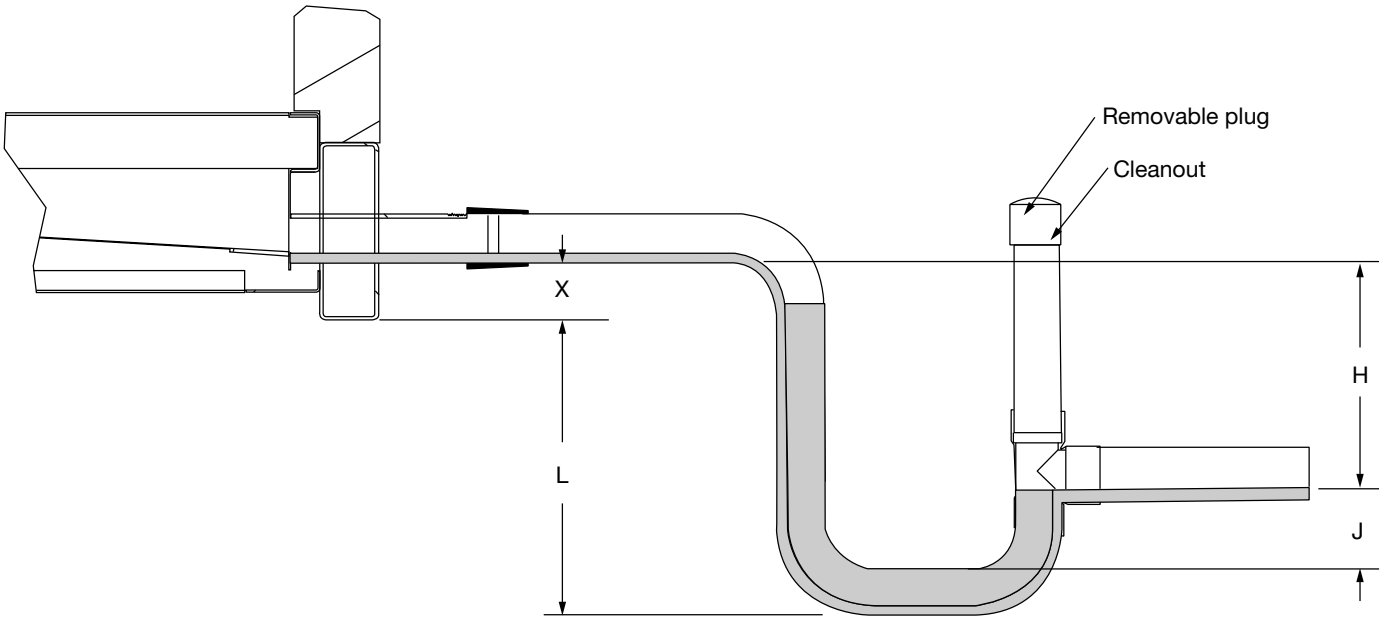
Appendix B: Positive and Negative Pressure Trapping

Positive Pressure Trapping



K = Minimum 0.5” [13 mm]
H = 0.5” [13 mm] + maximum total static pressure
X = 1.9375” [49 mm] if unit has a 6” [152 mm] tubular steel base
L = H + K + pipe diameter + insulation – X

Negative Pressure Trapping



H = 1” [36 mm] (for each 1“ [25 mm] of maximum negative static pressure) + 1” [25 mm]
J = Half of H
X = 3.9375” [100 mm] if unit has a 6” [152 mm] tubular steel base
L = H + J + pipe diameter + insulation – X

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Appendix C: V-Cube™ Start-up Form and Checklist

IMPORTANT

- Complete this form for each unit and email, fax or mail to Nortek Air Solutions Canada immediately after start-up to validate warranty and to provide valuable information for personnel performing future maintenance or for factory assistance to address below.
- Read the Installation, Operation and Maintenance Instructions Manual and the Venmar CES Control System Keypad Operation Guide and the Sequence of Operation before proceeding.
- Leave a copy of this report with the Owner and at the unit for future reference and permanent record.
- To ensure proper operation of each unit, qualified personnel should perform the start-up, complete the checklist and report.
- All units are functionally tested except when shipped in multiple pieces. Start-up adjustments may be required. If the unit is shipped as a single piece, blowers and compressors (if equipped) are set up to run correctly when power is connected. If any blower is running backwards or compressor is making loud noises, disconnect power and switch two leads (on three-phase power) to ensure proper rotation and avoid damage.
- If units are equipped with compressors, power must be turned on for **24 hours prior to a call** for cooling, for the compressor crank case heaters to be energizing to prevent possible damage.
- The Bacview keypad located at the control panel will allow for manual override for start-up, mode of operation selection and includes an internal time clock if remote interlocks are not provided.

Nortek Air Solutions Canada Inc.
200 Carter
St-Leonard-d'Aston, QC
Canada J0C 1M0

Email to Tech Support: venmarservice@venmarces.com
Fax: 899-319-2612
Phone: 1-866-483-6627

Unit Identification Information

Project: _____
Job Name: _____
Job Address:
_____
_____
Model Number: _____
Serial Number: _____
Tag: _____
Jobsite Contact: _____
Email: _____
Telephone: _____

Table C1: Pre Start-up Checklist

	Checklist Item	Yes	N/A
1	Is the electrical disconnect set to the 'Off' position?		
2	Have the split section joints been properly installed on multi-sectional units?		
3	Have all holes made by the Installing Contractor in the casing, partitions or floor been well sealed to prevent air and/or water infiltration?		
4	Have obstructive packaging, objects near or in fans, dampers, etc. been removed?		
	a. Has the inside of the unit been cleaned of all debris?		
5	Have all retaining bolts on fan isolation bases been removed?		
	a. Do all the fan impellers rotate freely?		
	b. Are all fan impellers and drive set screws tight?		
	c. Are all the fan bearing set screws or locking collars tight?		
	d. Are all fan belts aligned and have proper tension?		
	e. Are the fan flexible joint connections well attached?		
6	Are all air filters installed and clean?		
	a. Are all face-mounted filters attached with four clips each?		
	b. Do all sliding filters have a retainer at the end track and well attached blank-offs?		
	c. Are the filter pressure differential gauges, switches or sensors free of dirt and set at a value satisfactory to the end user to trigger a filter change?		

Serial Number: _____

Table C1: Pre Start-up Checklist

	Checklist Item	Yes	N/A
7	Have coils been checked for fin damage and dirt, straightened with a fin comb and cleaned (not applicable to brazed aluminum heat exchangers)?		
	a. Are all pipe connections tight and have they been checked for damage that may have occurred during shipping or installation?		
	b. Has the piping to the coils and WSHP/WCC been completed and have the piping lines been flushed, filled, vented and tested at 1.25 times the operating pressure?		
8	Scroll compressor RIS vibration isolator bolts are factory tightened to the correct torque setting for operation and do not require field adjustment.		
	a. Are the refrigerant components and piping in good condition and have no damage or leaks from shipping and/or installation?		
	b. Are the refrigerant lines spaced at least 1" apart and from the compressor after shipping and installation?		
	c. Are the refrigerant line clamps still secure and have their rubber lining?		
9	Are all motorized damper control arms, control rods and shafts tight?		
	a. Do all non-motorized dampers rotate freely?		
10	Is the ductwork connected, complete and free of obstructions?		
11	Have all condensate drain connections been trapped, installed correctly and filled?		
12	Have all factory internal high and low voltage wiring connections been properly re-connected at all unit split sections?		
13	Are all shipped loose or field supplied components correctly installed and wired?		
14	Has the wiring diagram been marked up accordingly and left with the unit?		
15	Has the power supply and control wiring been inspected and approved by the Local Authorities?		
16	Have factory and field wiring connections been checked and tightened?		
17	Check that all settings of control are in accordance with the wiring schematic.		
18	Check that all fuses are properly installed in holders.		
19	Is voltage at the disconnect switch within 10% of nameplate and are phase-to-phase readings within 2% of nameplate?		
20	Have field piping and venting installation, connections for heating and cooling options been completed and tested?		
21	Are heating and cooling enable switches set to the 'Off' position?		
22	If unit is equipped with an electric coil, check that the installation and pre start-up checks have been completed per Appendix E.		
23	Have all safety switches, overloads or other devices that are manual reset been checked and reset?		
24	If unit is are equipped with compressors, has power been turned on for 24 hours prior to a call for cooling?		

Serial Number: _____

Table C2: Start-up Checklist

	Checklist Item	Yes	N/A
1	Before proceeding, complete the Pre Start-up Checklist.		
2	Check that all access panels or doors are closed.		
3	If units are equipped with compressors, feel the compressor crank cases. They should be warm if the disconnect has been on for at least 24 hours. This will assure that no refrigerant liquid is present in the crank case, which could cause compressor damage or failure to occur on start-up. Otherwise turn the main disconnect to the 'On' position.		
4	The unit can be started by using the keypad and selecting the mode of operation from the Keypad Operation Guide and the Sequence of Operation. Disable the heating and cooling functions and set the unit to the occupied mode to bump start the fan wheel(s) to check their operation.		
5	If units are equipped with dampers, check that dampers are operating properly.		
6	Check that the fan wheel(s) are rotating in the correct direction.		
7	Adjust the fan motor VFD(s) to the correct air volume/Hertz.		
8	For occupied mode adjust outside and mixed or recirculation air damper positioners to achieve the required air volumes.		
9	Re-check the voltage at the disconnect switch against the nameplate and against phase-to-phase readings on three-phase with all blower(s) operating. If the voltage is not within 10% of rated or 2% of phase-to-phase have the condition corrected before continuing start-up.		
10	Check amperage draw to each motor on each phase against motor nameplate FLA. If significantly different, check ductwork static and/or take corrective action.		
11	Before activating the compressor(s), ensure that any water shut-off valves are open and that water is circulating through the water-to-refrigerant heat exchanger. Check the incoming line water pressure to ensure it is within design and acceptable limits.		
12	Enable the cooling mode of operation. Check if the sound of the compressor is normal or if there is excessive vibration.		
13	Check all field and factory refrigerant and water piping connections for leaks and correct.		
14	Operate the refrigerant system near full load conditions in both heating and cooling modes and check sub-cooling and superheat against values in Appendix L, Table L1. If readings do not match, adjust the refrigerant charge. Refer to Appendix L for information on adjusting the refrigerant charge.		
15	On units with WCC, after a few minutes of operation:		
	a. Check the supply discharge temperature status on the keypad for cooling air delivery. Measure the temperature difference between entering and leaving water. In cooling mode, the temperature difference should be approximately 1.5 times greater than the heating mode temperature difference. For example, if the cooling temperature difference is 15°F [8.3°C], the heating temperature difference should be approximately 7°F to 10°F [3.9°C to 5.6°C]. Adjust the combination shut-off/balancing valve in the return line to a water flow rate which will result in the 7°F to 10°F [3.9°C to 5.6°C] difference. Alternatively, if a flow measuring valve or pressure gauge connections are included, take the flow reading or pressure drop compared to the submittal information and adjust the shut-off/balancing valve in the return line to the correct flow/pressure drop reading.		
	b. Measure the temperature difference between entering and leaving air and entering and leaving water. With entering water of 60°F to 80°F [15.6°C to 26.7°C], leaving temperature should rise through the unit (should not exceed 35°F [19.4°C]). If the air temperature exceeds 35°F [19.4°C], then the water flow rate is inadequate or the airflow rate may be low and a second check may be required after airflow balancing.		
16	On units with electric heating coils, check supply air proving interlock switch setting to ensure minimum supply airflow prior to operation.		
17	Enable heating options and check the operation according to sequence; for electric coils, see electric heating coil and controls information in Appendix E.		
18	For electric heating coil option, check the amp draw on each stage, the operation of the sequence or SCR controller and the coil for any hot spots.		
19	Check the operation of the control options provided on the unit.		
20	Check the setpoints on the DDC Points Reference, adjust and record changes as required.		
21	Check that air balance has been completed for both occupied and unoccupied operation.		
22	When unit has achieved steady state, take measurements and complete readings section of the Start-up Form and Checklist in Appendix C. Send copy of the completed Start-up Form and Checklist to Nortek Air Solutions Canada to validate warranty. Maintain a copy of the report at the unit for future reference.		
23	Once completed, return setpoints to original or required values, return the unit to the correct mode of operation and adjust the time clock if required.		

Start-up Readings

Serial Number: _____

- Allow unit to reach steady state before taking readings.
- Complete based on options included with unit.

Nameplate voltage						
Input voltage	L1–L2		L2–L3		L1–L3	

Table C3: Start-up Readings – Supply Fans

	Rotation Correct	Full Load Amps (Nameplate Amps)	Amp Draw			O/L Amp Setting	Hertz	RPM
			L1	L2	L3			
Fan 1								
Fan 2								
Fan 3								
Fan 4								
Fan 5								
Fan 6								
Fan 7								
Fan 8								
Fan 9								
Fan 10								
Fan 11								
Fan 12								

Table C4: Start-up Readings – Condenser Fans

	Rotation Correct	Full Load Amps (Nameplate Amps)	Amp Draw			O/L Amp Setting	Hertz	RPM
			L1	L2	L3			
Fan 1								
Fan 2								
Fan 3								
Fan 4								
Fan 5								
Fan 6								
Fan 7								
Fan 8								
Fan 9								
Fan 10								
Fan 11								
Fan 12								

Serial Number: _____

Table C5: Start-up Readings – Compressors

	Full Load Amps (Nameplate Amps)	Amp Draw			After compressor has been running for 15 minutes, check for the following:					
		L1	L2	L3	Suction Pressure	Discharge Pressure	Superheat	Liquid Sub-cooling	Hot Gas Bypass Functioning	Outdoor Ambient Temperature During AC Cooling Start-up (°F/°C)
Compressor 1										
Compressor 2										
Compressor 3										
Compressor 4										
Compressor 5										
Compressor 6										
Compressor 7										
Compressor 8										
Compressor 9										
Compressor 10										
Compressor 11										
Compressor 12										
Compressor 13										
Compressor 14										
Compressor 15										
Compressor 16										

Serial Number: _____

Table C6: Start-up Readings – Water Source Heat Pump (WSHP)/Water Cooled Condenser (WCC)

	Waterside Cooling Mode			Waterside Heating Mode					
	Entering Temperature (°F/°C)	Leaving Temperature (°F/°C)	Temperature Difference (°F/°C)	Entering Temperature (°F/°C)	Leaving Temperature (°F/°C)	Temperature Difference (°F/°C)	Entering Pressure (PSI)	Leaving Pressure (PSI)	US GPM
Condenser 1									
Condenser 2									
Condenser 3									
Condenser 4									
Condenser 5									
Condenser 6									
Condenser 7									
Condenser 8									
Condenser 9									
Condenser 10									
Condenser 11									
Condenser 12									
Condenser 13									
Condenser 14									
Condenser 15									
Condenser 16									

Table C7: Start-up Readings – Electric Heating Coil

	Stage	L1 Amps	L2 Amps	L3 Amps	Check for Hot Pots
1					
2					
3					
4					
5					
6					

This unit has been checked out and started according with the above procedures and completed forms and is operating satisfactorily. After 24 hours of satisfactory operation shut-down the unit and check all foundation bolts, shaft bearings, drive set screws, valve train and terminals. Tighten where required.

Additional Comments:

_____

_____

_____

_____

Start-up

By: _____
Company Name: _____
Date: _____
Email: _____
Telephone: _____
Email to Tech Support: venmarservice@venmarces.com
or Fax to: 819-399-2612.

Appendix D: HEPA Filter Installation

These instructions are for installing AAF HEPA filters (11½" depth) into AAF HEPA holding frames. The holding frames are available in multiple sizes and materials, but include the PN series of 30619XX-XXX, where the X's vary with frame size and material. All frames, latches, extension legs and filters are sold separately. Please read the entire installation instructions before beginning the installation process.

Install filters into the HEPA holding frames only after the frames have been securely installed into existing ductwork or housing. Frames should be bolted or pop riveted together into the permanent structure through the predrilled holes around the outside perimeter of the frames. Frames should be sufficiently caulked and sealed to prevent any air bypass or leakage.

Required tools for filter installation:

- T-handle Hexkey, size 5/32"

Framing Components Required:

- AAF HEPA holding frames – PN 30619XXXXX
- Leg extensions, four per frame – PN 3061991- 00X
- Latches, four per frame – PN 3062007-00X

Figure D1: Leg extensions and latches

Step 1

At the inside corner of each frame are four tabs, two per side. Place a leg extension over the four tabs as shown in Figure D2 below, then pull back on the leg extension locking it into place.

Figure D2: Place leg extensions over the frame tabs, then pull back to lock the leg extension into place

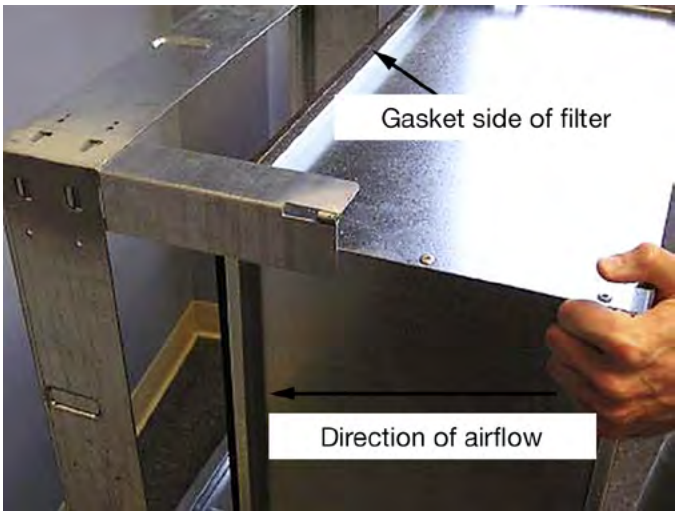
Repeat Step 1 with each of the four corners. The frame with leg extensions should look like Figure D3.

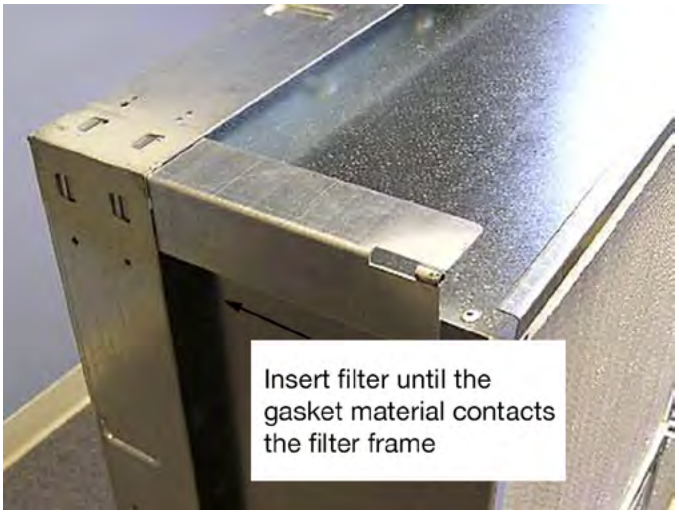
Figure D3: Frame with leg extensions installed

Step 2

Insert the HEPA filter into the HEPA holding frame. The HEPA should be installed with the gasket side of the filter facing the frame. Insert the filter as far into the frame as possible, so that the gasket material is contacting the frame (see Figure D4 below).

Figure D4: Insert HEPA filter into frame, until the gasket comes in contact with the holding frame





The filter should now be resting inside of the holding frame as shown to the left. When installing the filters into a frame bank of multiple frames, install the lower filters first so that the upper filters can rest on the lower filters.

Figure D5: Filter placed inside of frame

Step 3

Place a latch so that it overlaps the leg extension, as shown below in Figure D6. Align the latch's cap screw with the threaded coupling on the end of the leg extension and tighten using the hexkey. Tighten the cap screw until there is an approximately ¼" gap between the latch and the leg extension coupling as shown below in Figure D7. Repeat this step with all four corners.

Figure D6: Latch overlapping leg extension

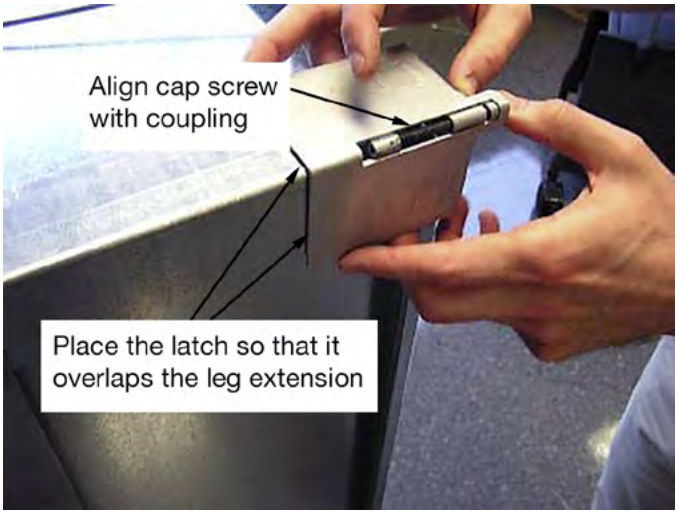


Figure D7: Tighten cap screw to ¼" of the coupling

Step 4

Once all four corner latches have been tightened within ¼" of the leg extension coupling, complete the installation by tightening each corner until the latch and leg extension coupling meet, as illustrated in Figure D8.

Figure D8: Tighten until latch and coupling meet

Once all four corners have been tightened, the filter should now be properly seated and sealed.

Repeat the process with all remaining filters working from the bottom to the top.

Figure D9: Properly installed filter

Appendix E: Electric Heating Coil and Controls Information

This electric heating coil module covered by this appendix is a component of a "Listed" product, subject to the guidelines of application as designated by the Certifying Agency and outlined in the Appliance Manufacturer's Installation and Operation Instructions.

The information provided in this appendix applies to the electric heating coil module, installed in the appliance and to its operation, maintenance and service. Refer to the appliance Manufacturer's instructions for information related to all other components.

1 – Mechanical Installation of Electric Coil Heaters

1.1 Handling

1.1.1 Remove the shipping covers just before installation.
1.1.2 Inspect the heater carefully and report any damage to the Manufacturer.

Do not install a damaged heater.

1.2 Installation

Heater Position

1.2.1 The axis of the duct must always be perpendicular to the face of the heater.
1.2.2 The heating elements must always be installed horizontally.

Model SC or ST (Slip-in Type)

1.2.3 Cut an opening in the side of the duct.
1.2.4 Slip the heater into the duct until the hole is completely covered by flanges around the heater.
1.2.5 Fasten the heater to the duct with sheet metal screws and seal openings with a suitable sealing compound.
1.2.6 If the heater is heavy, use additional hangers to support the heater.

Model FC or FT (Flanged Type)

1.2.7 Flange both ends of the duct outwards on three sides to match the heater's flanges.
1.2.8 Fasten the heater to the duct with sheet metal screws (for heavy heaters, use nuts and bolts and additional hangers to support the heater).
1.2.9 Seal openings with a suitable sealing compound.

IMPORTANT

- Do not install spray humidifiers upstream of duct. Install it downstream instead.
- Do not cover the control box with thermal insulating materials.
- Use special air intake louvers of weatherproof construction for pre-heat duct heaters to avoid intake of water or snow particles.
- Make sure that motorized damper blades are not blocked with snow or dirt. Inspect the dampers regularly to ensure a suitable airflow.

2 – Electrical Installation of Electric Coil Heaters

2.1 Disconnect Power Source

Disconnect all power sources before opening the control box and working within.

2.2 Read Nameplate

Read the nameplate carefully and consult wiring diagram before starting to wire.

2.3 Supply Wires

Use only wires suitable for 167°F [75°C]. Wires shall be sized according to the Canadian Electrical Code requirements. All wires must be brought in through knockouts.

2.4 Disconnecting Means

Install a disconnect switch close to the heater according to the code unless a disconnect switch is already built into the heater.

2.5 Control Circuit Wiring

Use Class II wiring for control circuit connections to the duct heater.

2.6 Magnetic Contactors

If magnetic contactors are mounted outside of the duct heater, use only contactors approved for:

- 250,000 operations when controlled by auto-reset thermal cut-out (A) and by other switching devices in series with this cut-out (thermostat, step controller, airflow switch, etc.).
- 100,000 operations when controlled by auto-reset thermal cut-out (A) alone.
- 100,000 operations when controlled by auto-reset thermal cut-out (A) plus manual reset cut-out in series (A and M).
- 6,000 operations when controlled by manual reset cutout (M) alone.

2.7 External Controls Ratings

Rating of external control devices shall be suitable for handling the VA ratings as marked on the nameplate; otherwise, a backup relay must be used.

2.8 Airflow Interlock

Heaters are generally supplied with one extra terminal marked for fan interlock or air sensing device connection. Remove jumper between terminals 'I' and 'C' before connecting the fan interlock. Select a suitable airflow sensing device of the differential pressure sensing type, with snap acting contacts. A slow make, slow brake device may cause undue cycling and in some instances chattering of the contactors. When fresh air dampers are used, make

sure the heater is properly interlocked to prevent it from being energized before the damper is fully open.

3 – Operating Electric Coil Heaters

3.1 Minimum Airflow

Ensure that sufficient airflow as marked on the nameplate is passing through the heater. Airflow should be evenly distributed across the entire face of the heater. Use air turning vane at duct elbows and splitter damper at duct branchoffs to streamline the airflow in the heater. Use suitable airflow sensing device or interlock the heater with fan. An insufficient airflow will lead to the opening of the auto-reset thermal cut-out or damage to the heating elements.

3.2 Warning

The air flowing through the duct where the heater is installed shall not contain any combustible particles, nor any flammable vapor or gas.

3.3 Air Temperature

The air temperature should not exceed 120°F [49°C] at the heater outlet.

3.4 Minimum Static Pressure and Air Direction

The heater is protected by a differential pressure switch. To keep the contact of this switch closed, it is necessary to maintain a minimum total pressure of 0.07" of water for a constant flow.

3.5 Manual Reset Thermal Cut-out

This protection device is standard on all heaters of less than 300V and 30 kW and is optional on all other heaters. Please check the auto-reset thermal cut-out before resetting the manual thermal cut-out. If any defect has been detected in the auto-reset thermal cut-out, it will be necessary to replace it before resetting the manual reset thermal cut-out.

4 – Maintenance

All electric coil heaters have been designed to operate long term without problems. Those responsible for equipment and maintenance should be aware of the following suggestions.

4.1 Visual Inspection

It is strongly recommended to complete a periodic inspection. This precautionary step will help to keep your installations operating well. Note these eventual first signs of problems:

- Accumulation of dust on the heating elements.
- Signs of overheating on the heater frame.
- Traces of water or rust on the control box.

4.2 Electrical Inspection

Two weeks after start-up, all electric connections to contactors should be checked and tightened up. Before each heating season, check the resistance between the heating elements and ground. It is also recommended to check the electrical connections to heating elements, magnetic contactors and main power lugs. This inspection is recommended monthly during the first four months of operation. After that, two inspections per heating season are sufficient.

4.3 Checkpoints

- Check all fuses.
- Check the resistance to ground for each circuit.
- Check the resistance phase-to-phase for each circuit.
- Check the tightening of connections at all contactors and heating elements.
- Check all contactors.

4.4 Off-season Maintenance

Where tubular heating elements are used, it is strongly recommended that you start the heating system from time to time. This precaution will prevent moisture from percolating through the terminal gaskets into the heating element and accumulating in the insulating powder. Should a heater be shut off for a long period, we recommend that you check carefully the resistance to ground for each circuit. It is important not to power a heater when too low a resistance to ground has been measured. It is also recommended to pay attention to any other heater operating in normal conditions. Control components such as step controllers or modulating valves (SCR) should be maintained and checked according to respective manufacturers instructions. Any defective components should be replaced only with identical original parts.

Appendix F: Extended Dormant Unit Maintenance Procedure

The following procedures must be applied to any unit which is stored for a period exceeding one month, which are required in order to maintain our warranty. Failure to comply with the procedures outlined below may result in damage and will void unit warranty.

1. Unit must be stored indoors in a clean, dry and tempered environment, heated in the winter and air cooled in the summer. Ambient air conditions should be from 50°F to 75°F with percentage RH from 10% to 50%. The unit needs to be stored in a warehouse (or some type of enclosure). **Storing units outdoors is contraindicated and will void our warranty.**
2. Unit must be stored on a level surface with the weight of the equipment evenly distributed through its base. The unit location must be free from excessive vibration and accidental impacts.
3. Once the unit has been unloaded in its resting location, the plastic wrapping must be removed from the unit **by cutting along the corner edges** in order to perform proper inspections and maintenance on the equipment. The plastic wrapping should be kept and re-applied to the unit when the unit will finally be shipped to the jobsite.
4. If applicable, **a certified/qualified Refrigeration Technician should** record refrigerant pressures on all compressors at time of storage. Each compressor must maintain refrigerant pressure in the system.
5. If applicable, **a certified/qualified Refrigeration Technician should** check refrigerant pressure in each compressor every three months. Refrigerant pressure must be maintained in the system. If zero pressure is found, this indicates a leak in the system. Leak(s) must be identified and repaired. A holding pressure must then be re-installed.
6. Rotate blower impellers by hand every two months; grease fan bearings as required following proper practices. Do not over grease the bearings as this may rupture the seals and lead to premature bearing failure during operation.
7. Ensure that all unit doors are kept closed.
8. Continue above maintenance schedule until unit start-up.

For all checks listed above please complete the Extended Dormant Unit Maintenance Checklist below and send a copy to the Nortek Air Solutions Canada Service Department **every six months and when unit is put into service.**

If the unit has been dormant for an extended period after initial start-up, all start-up checks should be repeated before operating the unit. Refer to the V-Cube™ Start-up Form and Checklist in Appendix C and complete these checks. Failure to comply with the above recommendations may result in component failure and surface corrosion on the interior and exterior of the unit.

Please note that if the unit is being stored outdoors or remains dormant for an extended period after initial start-up, this may result in condensation within the unit which could result in premature degradation of the unit and potential issues within the control panel. In this event, the installation of a desiccant pouch in the control cabinet is highly recommended, all ventilation ducts should be capped/covered to prevent chimney effect, all liquid pipes (water or glycol mixture) should be drained or capped off if necessary and all peripheral electrical penetrations should be properly sealed.

IMPORTANT

- Complete the Extended Dormant Unit Maintenance Checklist below, send a copy to Nortek Air Solutions Canada Service Department at the below email address or fax every six months and when unit is put into service, to validate warranty and to provide valuable information to personnel performing future maintenance or for factory assistance.
- Leave a copy of this report with the Owner and at the unit for future reference and permanent record.

Additional Comments:

_____

_____

_____

_____

Email to Tech Support: venmarservice@venmarces.com
Fax: 899-319-2612

Unit Identification Information

Project: _____
Job Name: _____
Job Address: _____
Model Number: _____
Serial Number: _____
Tag: _____
Jobsite Contact: _____
Email: _____
Telephone: _____

Maintenance

By: _____
Company Name: _____
Date: _____
Email: _____
Telephone: _____

Table F1: Extended Dormant Unit Maintenance Checklist

Item	Description	Yes	No
1	Is the unit stored indoors in a clean, dry environment?		
	Is the indoor storage facility temperature regulated to within 50°F to 75°F?		
	Is the indoor storage facility humidity regulated to within 10% to 50% RH?		
2	Is the unit mounted on a level surface along the perimeter of the base with weight evenly distributed?		
3	Has the plastic wrapping been removed from the unit to perform inspection and maintenance?		
	Has the plastic wrapping been saved for future use?		
	Has the plastic wrapping been re-applied to the unit when the unit has been shipped to jobsite?		
Recommend	Has a desiccant pouch been placed in the control panel?		

Item	Description	Inspection Date/Reading					
4	**Refrigerant pressure at storage**	**Date**	**PSIG**				
	Compressor 1						
	Compressor 2						
	Compressor 3						
	Compressor 4						
	Compressor 5						
	Compressor 6						
	Compressor 7						
	Compressor 8						
	Compressor 9						
	Compressor 10						
	Compressor 11						
	Compressor 12						
	Compressor 13						
	Compressor 14						
	Compressor 15						
	Compressor 16						

Table F1: Extended Dormant Unit Maintenance Checklist

5	**Refrigerant pressure every three months**	**Date**	**PSIG**	**Date**	**PSIG**	**Date**	**PSIG**
	Compressor 1						
	Compressor 2						
	Compressor 3						
	Compressor 4						
	Compressor 5						
	Compressor 6						
	Compressor 7						
	Compressor 8						
	Compressor 9						
	Compressor 10						
	Compressor 11						
	Compressor 12						
	Compressor 13						
	Compressor 14						
	Compressor 15						
	Compressor 16						
6	**Rotate blower impellers every two months**	**Date**	**Date**	**Date**	**Date**	**Date**	**Date**
	Supply						
	Other						
	Grease fan bearings as required						
	Supply						
	Other						

Appendix G: V-Cube™ Maintenance Summary Chart

Table G1: V-Cube Maintenance Summary Chart

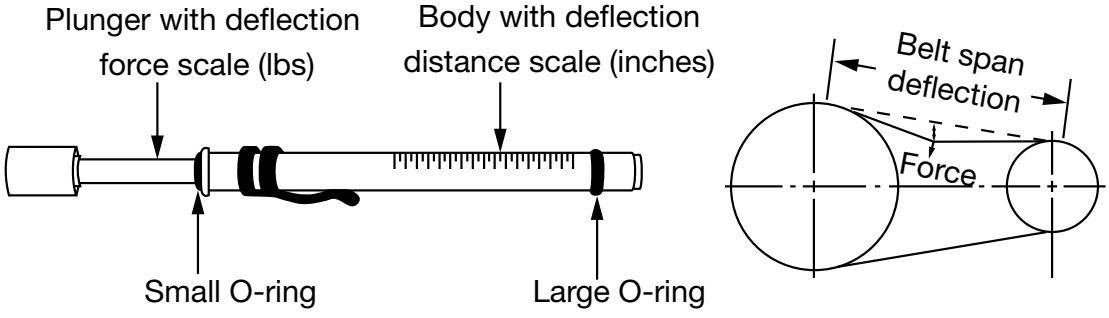
Item	No.	Description	Monthly	Quarterly	Semi-annually	Annually
General	1	Inspect the general condition of the unit.	x			
	2	Remove any dirt or debris.	x			
	3	Check for unusual noise or vibration.	x			
	4	Lubricate the door latch mechanisms.				x
Fans	5	Clean fans with stream of water.			x	
	6	Align or replace belts and drives.			x	
	7	Adjust belt tension.			x	
	8	Check motor voltage and current.			x	
	9	Lubricate the motor and shaft bearings.			x	
	10	Lubricate motor base adjusting screws.			x	
Dampers	11	Visual inspection for dirt or leakage.		x		
	12	Lubricate damper linkage.			x	
Air filters	13	Clean and replace prefilters.		x		
	14	Clean and replace final filters.			x	
	15	Inspect holding frames/sliding rack.				x
Coils	16	Clean the coils.				x
	17	Winterize the water coil.			x	
Electric	34	Verify all electrical connections; tighten if necessary.				x
	35	Verify all fuse holders.				x
	36	Verify all motor overload settings.				x
Cooling section	39	Look for oil on all refrigeration components (including coils, compressors, etc.) to indicate a refrigerant leak.		x		
	40	Verify for proper superheat.		x		
	41	Verify each circuit refrigerant site glass when the circuit is operating under steady state, full load conditions. It should be full and clear. If not, look for refrigerant leaks.		x		

Appendix H: Measuring and Adjusting V-belt Tension

Table H1: Measuring V-belt Tension

V-belt Cross Section	Small Sheave Diameter Range (Inches)	Recommended Deflection Force (lbs)		
		Initial Installation	Retensioned	
			Maximum	Minimum
A	3.00 to 3.40	3.3	2.9	2.2
	3.60 to 4.20	3.5	3.1	2.4
	4.60 to 6.00	3.7	3.3	2.5
B	4.60 to 5.40	6.0	5.1	4.0
	5.60 to 7.40	6.3	5.5	4.2
	8.60 to 9.40	6.6	5.7	4.4
C	7.00 to 8.50	13.2	11.5	8.8
	9.00 to 12.00	13.9	12.1	9.3
	13.00 to 16.00	14.6	12.6	9.7
D	12.00 to 15.50	26.5	22.9	17.6
	16.00 to 18.00	27.8	24.3	18.7
	22.00 to 27.00	29.1	25.6	19.6
E	17.70 to 23.60	39.7	34.4	26.5
	23.70 to 31.50	41.7	36.2	27.8
	31.60 to 39.60	43.7	37.9	29.1
AX	2.10 to 3.40	4.4	3.7	2.9
	3.60 to 4.20	4.6	4.0	3.1
	4.60 to 6.00	4.9	4.2	3.3
BX	3.70 to 5.40	7.7	6.6	5.1
	5.60 to 7.40	8.2	7.1	5.5
	8.60 to 9.40	8.6	7.5	5.7
CX	5.80 to 8.50	17.2	15.0	11.5
	9.00 to 12.00	18.1	15.7	12.1
	13.00 to 16.00	19.0	16.5	12.8
3V	2.65 to 3.35	5.5	4.8	3.9
	3.65 to 4.12	6.4	5.7	4.4
	4.50 to 5.60	7.5	6.6	5.1
	6.00 to 10.60	8.6	7.5	5.7
5V	7.10 to 8.50	19.2	16.7	13.0
	9.00 to 11.80	23.3	20.3	15.6
	12.50 to 16.00	27.3	23.8	18.5
8V	12.50 to 16.00	50.9	44.3	34.4
	17.00 to 20.00	57.1	49.8	38.6
	21.00 to 24.80	61.3	53.3	41.4
3VX	2.20 to 3.35	5.5	4.8	3.9
	3.65 to 4.12	6.4	5.7	4.4
	4.50 to 5.60	7.5	6.6	5.0
	6.00 to 10.60	8.6	7.5	5.7
5VX	4.40 to 8.50	19.2	16.7	13.0
	9.00 to 11.80	23.3	20.3	15.6
	12.50 to 16.00	27.3	23.8	18.5

Figure H1: Belt tension adjustment

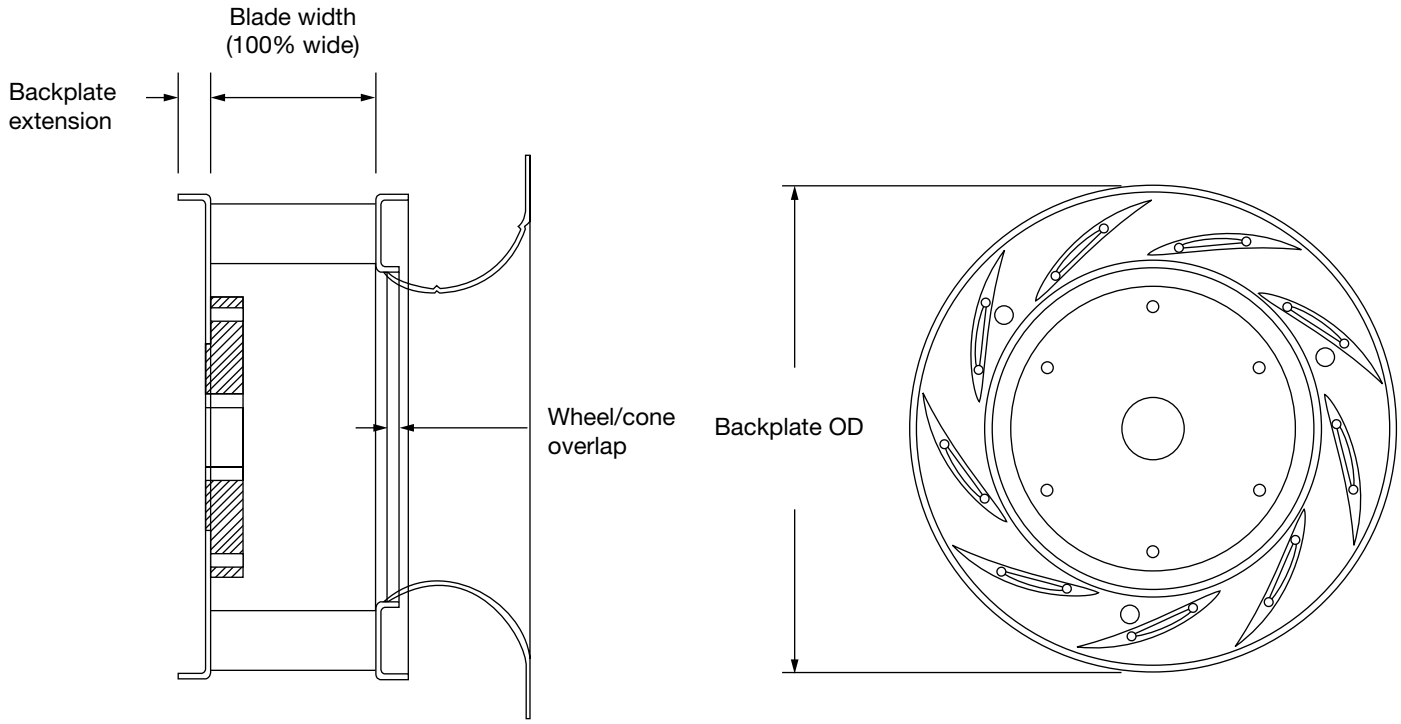


Appendix I: FANWALL® Inlet Cone Alignment

Table I1: FANWALL Wheel/Cone Alignment Dimensions (Inches)

Wheel Size	Backplate OD	Blade Width	Backplate Extension	Wheel/Cone Overlap
10	10.375	3.495	0.700	0.250
12	12.500	4.280	0.700	0.250
14	13.750	4.720	0.700	0.250
16	16.750	5.760	0.700	0.250
20	20.451	6.990	0.700	0.400
22	22.701	7.780	0.700	0.400

Figure I1: FANWALL inlet cone alignment



Appendix J: Filter Resistance and Latches

Table J1: Prefilters (MERV 8)

Depth	Nominal Size	Capacities (CFM)		Resistance @ Capacity (in. w.g.)		
		Medium	High	Medium	High	Final
2” [51 mm]	12” x 24” x 2” [305 x 610 x 51 mm] 24” x 24” x 2” [610 x 610 x 51 mm]	600 1,250	1,000 2,000	0.12 0.12	0.23 0.23	1.00 1.00
4” [102 mm]	12” x 24” x 4” [305 x 610 x 102 mm] 24” x 24” x 4” [610 x 610 x 102 mm]	600 1,200	1,200 2,400	0.12 0.12	0.27 0.27	1.00 1.00

Table J2: 4” [102 mm] Final Filters

Filter Efficiency	MERV Rating	Nominal Size	Capacities (CFM)	Resistance (in. w.g.)	
				Initial	Final
60–65%	MERV 11	12” x 24” x 4” [305 x 610 x 102 mm] 24” x 24” x 4” [610 x 610 x 102 mm]	1,000 2,000	0.45	1.50
80–85%	MERV 14	12” x 24” x 4” [305 x 610 x 102 mm] 24” x 24” x 4” [610 x 610 x 102 mm]	1,000 2,000	0.65	1.50
90–95%	MERV 15	12” x 24” x 4” [305 x 610 x 102 mm] 24” x 24” x 4” [610 x 610 x 102 mm]	1,000 2,000	0.75	1.50

Table J3: 12” [305 mm] Final Filters

Filter Efficiency	MERV Rating	Nominal Size	Capacities (CFM)	Resistance (in. w.g.)	
				Initial	Final
60–65%	MERV 11	12” x 24” x 12” [305 x 610 x 305 mm] 24” x 24” x 12” [610 x 610 x 305 mm]	1,000 2,000	0.39	1.50
80–85%	MERV 14	12” x 24” x 12” [305 x 610 x 305 mm] 24” x 24” x 12” [610 x 610 x 305 mm]	1,000 2,000	0.53	1.50
90–95%	MERV 15	12” x 24” x 12” [305 x 610 x 305 mm] 24” x 24” x 12” [610 x 610 x 305 mm]	1,000 2,000	0.58	1.50

Table J4: Filter Latches for Front of Upstream Loading/Access

Final Filter	Prefilter	Latch	Venmar CES PN
None	2”	C-70	207312240
	4”	C-86	19516104
4” nominal	None	C-86	19516104
	2”	Knock-on (4” + 2”)	500026048
	4”	Knock-on (4” + 4”)	500026049
12” HEPA	None	—	HEPA frame
	2”	VP-2	208290023
	4”	VP-4	19516310
12” double header	None	C-80	19516103
	2”	C-80/VP-2	19516103 / 208290023
	4”	C-80/VP-4	19516103 / 19516310

Appendix K: Troubleshooting

Table K1: Troubleshooting – V-Cube™

Symptom	Possible Cause	Corrective Action
	General	
Air supply too cold.	Supply air is unbalanced.	Check filters for blockage. Balance flow of supply air. Check operation of heating option. Adjust heating setpoint. Install a post-heat module.
Noisy unit.	Blower wheel is rubbing on other parts.	Adjust wheel or replace defective part.
	Blower wheel is out of alignment.	Remove the motor/blower assembly. Adjust the blower wheel.
	Sheaves are out of alignment.	Verify wheel alignment. Align belt using a straight edge.
	Excessive belt tension causes bearings to screech.	Adjust belt tension.
	Low belt tension causes belts to squeal.	Adjust belt tension.
	Ducts are vibrating.	Install flexible connections.
	Unit is too close to occupants.	Install a silencer.
Bearings wear down too quickly.	Excessive vibration.	Replace shaft and bearings. Verify wheel alignment.
	Belt too tight.	Adjust belt tension.
Poor airflow.	Fan wheel is turning the wrong direction.	Reverse rotation or motor so that wheel turns in the direction of the arrows shown on the fan.
	Rotation speed is too low.	Increase speed by increasing the diameter of motor sheave or installing a smaller fan sheave.
	Filters are blocked.	Replace filters.
	Air leakage.	Seal all leaks in ducts and unit walls.
	Fan belt is slipping.	Adjust belt tension.
Fan motor overload.	Low static pressure.	Verify presence of filters and other duct components. Set balancing damper so that it reduces the passage of air.
	Electric tension of motor is too low/high.	Adjust tension.
	Excessive fan speed.	Reduce blower speed.
	Low motor power.	Install more powerful motors.
Filters are out of filter rack.	Filters are too dirty and have been sucked into the unit.	Clean or change the filters and consider revising maintenance schedule.
	Filters are wet.	Water infiltration or condensation. See Water Issues section below.
	Filter rack is damaged.	Repair filter racks and re-install filters.
	Some filter clips are missing.	Order new clips from Nortek Air Solutions Canada.

Table K1: Troubleshooting – V-Cube™

Symptom	Possible Cause	Corrective Action
Water Issues		
Water carryover from wet cooling coil onto the floor, motor or fan housing.	Airflow is too high.	Lower airflow by adjusting the drive.
	Drain pan not properly draining.	Clean drain pan and ensure suction into the unit is not too high.
	Coil bulkhead penetration.	Be sure any field penetrations are sealed.
	Missing or improper intermediate drain pan.	Install or clean the intermediate drain pan.
Water inside the unit.	Unit was not properly sealed when installed.	Seal all section joints. Sections under negative pressure require special attention to sealing.
	Electrical or piping conduits not properly sealed.	Inspect and seal any holes made for electrical wires or piping conduits.
Drain pan not properly draining.	Trap is not properly installed.	Revise trap installation and dimensions.
	Unit is not installed on level.	Revise the level of curbs.
	Pressure exceeds the design.	Verify design pressure versus unit pressure and check the segment which houses the drain pan.
Prefilter is wet.	Outside air hood is shipped loose and was not well sealed when installed.	Re-install hood, ensuring the flange is properly sealed.
	Airflow exceeds design conditions and sucks water into the unit.	Re-design the hood or lower the CFM of the unit.
Refrigerant Issues		
Solenoid valve does not open.	No power to coil.	Check circuit connections.
	Defective solenoid coil.	Replace solenoid coil.
Too much refrigerant is being fed to the evaporator and the superheat is too low (cannot be adjusted).	Dirt or foreign material lodged in thermostatic expansion valve.	Disassemble valve, remove dirt and re-verify superheat.
	Defective thermostatic expansion valve.	Replace thermostatic expansion valve.
Compressors lockout on high head pressure or run at higher than design head pressure.	Insufficient fluid flow across condenser coil.	Clean dirty condenser coil. Comb damaged fin surface with fin comb. Tighten loose fan belt(s).
	Condenser fan failure.	Verify fan rotation. Verify fan RPM. Check fuses. Verify overload. Check fan controls. Check for motor burnout.
	High pressure control.	Check for proper setting.
	Service valve failure.	Discharge valve fully back sealed.
	Refrigerant overcharge.	Verify condenser subcooling (15°F [–9°C]). If above 15°F [–9°C], adjust charge based on maintaining suction pressure.
	Supply water temperature may be too high.	Verify water temperature rise entering and leaving unit to determine if adequate water is flowing.
	Water control valves not operating properly.	Verify and repair water control valves.
Condenser fan(s) short cycling.	Improperly set sequencing control.	Set for correct pressure and differential.

Appendix L: Adjusting Refrigerant Charge

CAUTION

The Clean Air Act of 1990 bans the intentional venting of refrigerant (CFCs and HCFCs) as of July 1, 1992. Approved methods of recovery, recycling or reclaiming must be followed. Fines and/or incarceration may be levied for non-compliance.

CAUTION

It is very important to make certain that the recycle or recovery equipment used is designed for R410a. The pressure of R410a refrigerant is approximately 60% greater than that of R22. Pressure gauges require a range up to 800 psig high side and 250 psig low side. Recovery cylinders require a 400 psig rating.

Adjusting the refrigerant charge of a system in the field must be based on determination of liquid sub-cooling and evaporator superheat. On a system with a TXV liquid sub-cooling is more representative of the charge than evaporator superheat but both measurements must be taken.

Before Charging

1. Unit being charged must be at or near full load conditions before adjusting the charge.
2. Units equipped with hot gas re-heat must be charged with the hot gas re-heat valves closed while the unit is in cooling mode to get the proper charge. After charging, unit must be operated in re-heat (dehumidification) mode to check for correct operation.
3. Units equipped with heat pump options must be charged in heating mode to get the proper charge. After charging, unit must be operated in cooling mode to check for correct charge. Charge may need to be adjusted for cooling mode. If adjustments are made in the cooling mode heating mode must be re-run to verify proper operation.
4. After adding or removing charge the system must be allowed to stabilize, typically 10–15 minutes, before making any other adjustments.
5. The type of unit and options determine the ranges for liquid sub-cooling and evaporator superheat. Refer to Table L1 when determining the proper sub-cooling and superheat.

Checking Liquid Sub-cooling

1. Measure the temperature of the liquid line as it leaves the condenser coil.
2. Read the gauge pressure at the liquid line close to the point where the temperature was taken. One must use liquid line pressure as it will vary from discharge pressure due to condenser coil pressure drop.
3. Convert the pressure obtained to a saturated temperature using the R410a refrigerant temperature verses pressure Table L2. Subtract the measured liquid line temperature from the saturated temperature to determine the liquid sub-cooling.
4. Compare calculated sub-cooling to Table L1 for the appropriate unit type and options.

Checking Evaporator Superheat

1. Measure the temperature of the suction line close to the compressor.
2. Read gauge pressure at the suction line close to the compressor.
3. Convert the pressure obtained to a saturated temperature using the R410a refrigerant temperature verses pressure in Table L2.
4. Subtract the saturated temperature from the measured suction line temperature to determine the evaporator superheat.
5. Compare calculated superheat to Table L1 for the appropriate unit type and options.

Table L1: Acceptable Refrigeration Circuit Values

Air Cooled Condenser or Air Source Heat Pump	
Sub-cooling	12–18°F
Sub-cooling with hot gas re-heat	15–22°F
Superheat	8–15°F
Water Cooled Condenser or Water Source Heat Pump	
Sub-cooling	4–8°F
Superheat	8–15°F

CAUTION

Thermal expansion valve must be adjusted to approximately 8°F to 15°F of suction superheat. Failure to have sufficient superheat will damage the compressor and void the warranty.

Adjusting Sub-cooling and Superheat Temperatures

1. The system is overcharged if the sub-cooling temperature is too high and the evaporator is fully loaded (low loads on the evaporator result in increased sub-cooling) and the evaporator superheat is within the temperature range as shown in Table L1 (high superheat results in increased sub-cooling).

CAUTION

Do not overcharge!

Refrigerant overcharging leads to excess refrigerant in the condenser coils resulting in elevated compressor discharge pressure.

2. Correct an overcharged system by reducing the amount of refrigerant in the system to lower the sub-cooling.
3. The system is undercharged if the superheat is too high and the sub-cooling is too low
4. Correct an undercharged system by adding refrigerant to the system to reduce superheat and raise sub-cooling.
5. If the sub-cooling is correct and the superheat is too high, the TXV may need adjustment to correct the superheat.

Table L2: R410a Refrigerant Temperature vs. Pressure

°F	PSIG	°F	PSIG	°F	PSIG	°F	PSIG	°F	PSIG
20	78.3	47	134.7	74	213.7	101	321.0	128	463.2
21	80.0	48	137.2	75	217.1	102	325.6	129	469.3
22	81.8	49	139.7	76	220.6	103	330.2	130	475.4
23	86.6	50	142.2	77	224.1	104	334.9	131	481.6
24	85.4	51	144.8	78	227.7	105	339.6	132	487.8
25	87.2	52	147.4	79	231.3	106	344.4	133	494.1
26	89.1	53	150.1	80	234.9	107	349.3	134	500.5
27	91.0	54	152.8	81	238.6	108	354.2	135	506.9
28	92.9	55	155.5	82	242.3	109	359.1	136	513.4
29	94.9	56	158.2	83	246.0	110	364.1	137	520.0
30	96.8	57	161.0	84	249.8	111	369.1	138	526.6
31	98.8	58	163.8	85	253.7	112	374.2	139	533.3
32	100.9	59	166.7	86	257.5	113	379.4	140	540.1
33	102.9	60	169.6	87	261.4	114	384.6	141	547.0
34	105.0	61	172.5	88	265.4	115	389.9	142	553.9
35	107.1	62	175.4	89	269.4	116	395.2	143	560.9
36	109.2	63	178.4	90	273.5	117	400.5	144	567.9
37	111.4	64	181.5	91	277.6	118	405.9	145	575.1
38	113.6	65	184.5	92	281.7	119	411.4	146	582.3
39	115.8	66	187.6	93	285.9	120	416.9	147	589.6
40	118.1	67	190.7	94	280.1	121	422.5	148	596.9
41	120.3	68	193.9	95	294.4	122	428.2	149	604.4
42	122.7	69	197.1	96	298.7	123	433.9	150	611.9
43	125.0	70	200.4	97	303.0	124	439.6		
44	127.4	71	203.6	98	307.5	125	445.4		
45	129.8	72	207.0	99	311.9	126	451.3		
46	132.2	73	210.3	100	316.4	127	457.3		

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