BC NPHA

Operator Training Manual

Dual Fuel Rooftop Units and Makeup Air Units

source: https://www.achrnews.com/articles/155050-advances-in-heat-pump-rooftop-units-for-cold-climates

How To Use This Guide

This guide is designed to make sure that when your dual fuel rooftop unit (RTU) or makeup air unit (MUA) installation is complete, you have all the information you need to operate and maintain it effectively and confidently.

It includes references and checklists you can use directly, as well as items you should request from your contractor before the project is finished. The checklist below shows everything covered in this guide:

- ☑ Items already included here
- ☐ Items you'll need to ask your contractor for

Contents

	Item	Notes/Description	Status
1. Equipment Overview			
1.1	Description and Diagram	A brief explanation of how the system works and labeled diagram of the system and its primary components *A general diagram is provided here; ask your contractor for a model-specific version.*	☑
1.2	How It Works	A high level overview of system operation *General overview has been provided, but model specific details should be provided by the contractor during your training session or handoff process.*	☐
1.3	Key Benefits and Limitations	Key benefits and limitations of the system	☑
1.4	System Operation	A summary of operating limits, recommended setpoints, backup heating considerations *These should be provided to occupants to improve efficiency and ensure comfort.*	☑
2. Commissioning and Project Handoff			
2.1	Equipment Spec Sheets	Equipment specification sheets (spec sheets) or manuals for each piece of equipment – Including make, model and serial number	☐
2.1	Equipment O&M Manuals	These provide details on how to operate and maintain the equipment	☐
2.2	Key Contacts List	A list of all key people to contact for questions, issues, warranty etc.	☐
2.3	Warranty Details	Warranty terms and expiry date	☐
2.4	Commissioning Report	The completed record showing the results of commissioning tests - it provides proof that the systems work	☐
2.5	What to Watch Out For	Dual fuel RTUs have a history of poor performance, typically due to improper commissioning - a brief list of common issues frequently identified during commissioning has been noted here for quick reference	☑
2.6	Training Session	This is not always done as part of a project handoff and likely needs to be requested *A sample training agenda is provided for reference.*	☐
2.7	Maintenance Requirements	This consists of a maintenance schedule and a troubleshooting guide *General examples for both documents have been provided, but the contractor should provide model specific details in the handoff documentation.*	☐
-	Digital Copies	Digital copies (USB / shared folder) of all above	☐

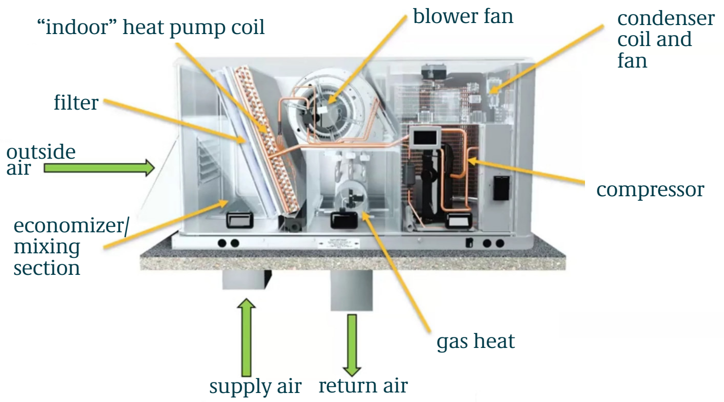
1. Equipment Overview

1.1. Description and Diagram

1.1.1. Dual Fuel RTU

Dual fuel rooftop units (RTUs) are packaged HVAC systems that provide heating, sometimes cooling, and ventilation to one or more spaces in a building. They deliver mixed air, meaning they blend outdoor air (OA) with return air (RA) from the space. A modulating damper adjusts the proportions of OA and RA to maintain proper ventilation.

In a dual fuel setup, the unit uses two heating sources: a heat pump as the primary source and gas fired heating as the backup. During moderate weather, the heat pump heats or cools the mixed air and delivers it to the space. When outdoor temperatures become too cold for the heat pump to meet the full heating load, the unit automatically switches to gas heat to ensure the spaces are comfortable year-round.



source: https://www.youtube.com/watch?v=quAPJIgsqKA

1.1.2. Dual Fuel MUA

A makeup air unit (MUA) is often referred to as a dedicated outdoor air system (DAOS). The main difference between a dual fuel RTU, and a dual fuel MUA is that the MUA delivers 100% OA, as shown below. Because the MUA only supplies air and does not remove it, it must work alongside separate exhaust systems – such as kitchen hoods or bathroom exhaust fans in residential units – to maintain proper ventilation and airflow balance in the building.

Because MUAs do not mix OA with preconditioned RA, they must heat or cool the full load of OA. This results in larger heating and cooling requirements compared to RTUs, often making MUAs heavier and sometimes requiring an electrical service upgrade when the unit is replaced.

Glossary of Terms

Commissioning – The process of testing and verifying that a system is installed correctly and operating as intended, including its performance and control settings.

Coefficient of Performance (COP) – A measure of heat pump efficiency. For example, a COP of 2.0 means the heat pump delivers twice as much heat energy as the electrical energy it consumes.

Defrost Cycle – A temporary mode where the heat pump reverses operation to melt frost that has built up on the outdoor coil.

Mixed Air Temperature (MAT) – The temperature of the air after outdoor air and return air have been combined in the RTU but before it passes across the heating or cooling coils.

Makeup Air Unit (MUA) – A MUA, also known as a **Dedicated Outdoor Air System (DOAS)** is a unit that brings in 100% fresh outdoor air to replace the air that's being exhausted from the building. It's used in places that need lots of fresh air or can't reuse indoor air – like kitchens or hallways in apartment buildings. MUAs usually provide heating and may also provide cooling when needed.

Outdoor Air Temperature (OAT) – The temperature of the outside air, used by the system to make control and operating decisions.

Return Air Temperature (RAT) – The temperature of the air returning from the conditioned space back to the RTU.

Room Temperature (RT) – The temperature of the room or area served by the RTU. If the unit serves several rooms, the average temperature of all those spaces is typically used.

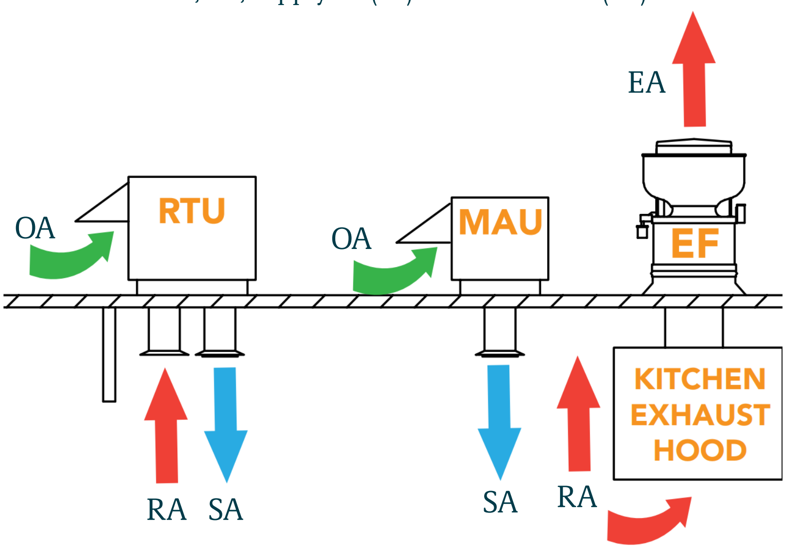
Rooftop Unit (RTU) – A packaged HVAC system installed on the roof. It pulls in a mix of fresh outdoor air and indoor return air and provides heating and often cooling to the space. Most standard RTUs use gas heat and direct-expansion (DX) cooling, with all components built into one compact unit.

Supply Air Temperature (SAT) – The temperature of the air as it leaves the HVAC unit and is delivered into the building.

Switchover Temperature – The outdoor temperature at which the system stops using the heat pump (primary heat source) and switches to a backup heating source (gas burner).

During the heating season, the heat pump in a MUA has a more limited operating range because it must condition 100% OA instead of partially warmed return air. To extend the heat pump's effective range, some MUAs are equipped with electric preheat coils that temper the OA before it reaches the heat pump coil. This allows the heat pump section to continue operating at lower outdoor temperatures than it otherwise could.

The photo below shows the difference between an RTU and MUA. It denotes the OA, RA, supply air (SA) and exhaust air (EA).



source: https://www.dialecticeng.com/insights/2017/08/11/commercial-kitchen-ventilation-ckv-design-and-recent innovations-and-developments-in-the-industry

1.2. How It Works

In both dual fuel RTUs and MUAs, the heat pump is the primary heating source and operates as long as it can meet the building's heating load. Rather than creating heat, a heat pump transfers heat from the OA into the supply air, making it much more efficient than gas heating for most of the year. However, as outdoor temperatures drop, the heat pump's capacity decreases significantly. When it can no longer meet the space heating demand, or when the OA becomes too cold for the heat pump's coils to operate effectively, the unit switches to gas heating.

The specific method for switching between the primary (heat pump) and secondary (gas) heating sources depends on the unit's programmed control sequences. General recommendations are provided in section 1.4 - System Operation.

But wait, how does it MOVE heat?

The heat pump uses a refrigerant with a boiling point that is roughly -50°C. This means that the refrigerant liquid absorbs heat from OA, converting it to a gas even in cold winter conditions. Because heat always flows from warm to cold, the refrigerant absorbs that heat, the system then compresses the refrigerant gas, making it very hot (hotter than the inside temperature), which is then 'pumped' to the indoor units through piping, and fans transfer the heat from the hot coil to the room.

It's not creating heat – it's just moving and concentrating the heat that's already in the air. Think of it like a sponge soaking up even small amounts of water and squeezing them out somewhere else. That's why a heat pump can still work in sub-zero temperatures: there's always at least a little heat in the air to capture.

1.3. Key Benefits and Limitations

1.3.1. Benefits

- **Reduced Emissions:** Dual fuel RTUs and MUAs significantly reduce natural gas use by relying on the heat pump as the primary heating source. When properly controlled and commissioned, this can cut gas consumption – and associated greenhouse gas (GHG) emissions – by up to 90%.
- **Reliable Comfort:** Both systems maintain dependable heating performance with an automatic gas backup. This ensures that even during very cold weather, when the heat pump cannot meet the full heating load, the building remains comfortable.
- **Cost Effective RTU Upgrades:** Upgrading a dual fuel RTU is often cost effective when the existing unit already includes direct-expansion (DX) cooling. Because the electrical infrastructure for cooling is already in place, RTU heat pump retrofits typically do not require major electrical or structural upgrades.

1.3.2. Limitations

- **MUA Design and Cost Considerations:** For dual fuel MUAs, the heat pump must heat 100% OA, which typically requires a much larger heat pump capacity than the original DX cooling system. As a result, MUA replacements or upgrades may still require electrical and structural modifications, even when converting from gas heat to a dual fuel configuration.
- **Cold Weather Performance Constraints:** Heat pump capacity drops significantly at low outdoor air temperatures (OATs). During colder periods, the system must rely heavily on the gas heating section, reducing the emissions savings as compared to systems that use electric resistance heat as backup.
- **Control Complexity:** Dual fuel systems require thorough commissioning to function as intended. Improper switchover temperatures, faulty sensors, or poorly tuned control sequences can lead to excessive gas use, diminished energy savings, and comfort issues. These control-related problems are commonly observed in dual fuel installations, which is why proper commissioning is critical for these units.

1.4. System Operation

The heat pump should act as the first stage of heating whenever outdoor conditions allow it to work effectively. Gas heat should only engage when the heat pump cannot maintain comfortable space conditions or when the OAT drops below the heat pump operating range. Proper supply air temperature (SAT) sensor placement (downstream of both heating sections) and realistic discharge air setpoints (SPs), are critical to performance.

1.4.1. Dual Fuel RTU Switchover

The typical switchover control for dual fuel RTUs is as follows:

- **Switchover based on OAT**

This approach is simple to set up but often results in more gas usage.

In this approach, the system switches from heat pump to gas heat when the OAT is below a programmed value. Many units ship with a default switchover setting around 0°C, to –1°C, although some new equipment can continue operating in heat pump mode down to –20°C, depending on the make and model.

Because this strategy uses a fixed temperature, it often causes the heat pump to shut off earlier than necessary, leading to more gas use.

If this strategy is selected, it is recommended that the switchover SP be below –3°C.

- **Switchover based on SAT or room temperature (RT)**

This approach is slightly more complex but provides the best overall GHG reductions when set up properly.

Instead of relying on a fixed outdoor temperature, this method switches to gas heat only when the heat pump can no longer meet the heating load. This is typically triggered when:

- The SAT drops too far below its SP; or
- The RT falls below the thermostat SP.

Because it reacts to how the unit is actually performing – not just the OAT – this method uses the heat pump more efficiently and reduces gas use. However, it is more complex, so it may not be the default setup and need to be requested. Some smaller RTUs with basic controls may not support this strategy.

1.4.1.1. RTU Economizer

For packaged dual fuel RTUs, one of the easiest ways to help the heat pump run longer in cold weather is to reduce how much cold OA the unit pulls in. Bringing in less OA means the mixed air going into the heat pump starts out warmer, making it easier for the heat pump to operate without switching over to gas heat.

Many larger RTUs are equipped with economizers, which can adjust the OA dampers to bring in only the amount of fresh air the space needs. Smaller units often have a fixed OA setting and cannot modulate airflow.

In units with economizers, demand-controlled ventilation (DCV) may also be used to control the amount of OA. In this case, a CO_2 sensor determines occupancy and reduces OA when fewer people are present. If your RTU has CO_2 sensors and DCV, ensure the system is set up correctly to maintain comfort and good indoor air quality while maximizing heat pump operation in cold weather.

1.4.2. Dual Fuel MUA Switchover

Because MUAs bring in 100% OA, the heat pump's coil is directly exposed to cold, humid conditions. When outdoor temperatures drop below about 7°C, the coil surface typically falls below freezing, causing moisture in the air to frost on the coil. This ice buildup can limit performance and may damage the coil. Although defrost cycles (usually active between 5–10°C) can clear the ice, they require extra energy, so MUAs generally need to switch to backup heat below 7°C.

To extend the heat pump's operating range, MUAs may use electric or glycol preheat to warm the incoming air before it reaches the coil. This can allow heat pump operation at lower temperatures – for example, down to –3°C instead of shutting off at 7°C.

If your unit is equipped with a preheat coil, a typical strategy is as follows.

- Enable preheat when OAT < 7°C.
- Enable gas heat when OAT < 0 to –3°C (the exact value depends on the preheat coil's capacity).

This approach reduces emissions by allowing the heat pump to operate for more hours before gas heating is needed.

2. Commissioning and Project Handoff

2.1. Spec Sheets and Manuals

Your contractor should provide a specification sheet (spec sheet) and manual for each piece of equipment that's installed. Because manuals often cover several different models, make sure you know the exact make and model of your unit; you can usually find this in the commissioning reports.

While these manuals are helpful, they're often long and hard to follow. That's why it's a good idea to also ask your contractor for a training session and a simplified user guide. These guides are shorter and can be helpful to understand how to operate and take care of your system day-to-day.

2.2. Key Contact List

Contact Type	Contact When?	Company / Name	Phone / Email
Equipment Manufacturer	For warranty questions or if you need information about the equipment. **Warranty end date: mmddyyyy** **Unit warranty must be registered with the manufacturer*		
Controller or Thermostat Manufacturer	For warranty questions or if you need information about the equipment.		
General Contractor (Installer)	For any questions about the system or if something isn't working within the warranty period; typically one year after install.		
Service Contractor (If different)	For repairs or issues that come up after the warranty period.		
Controls Specialist (If applicable)	For assistance with control sequencing, switchover logic, or building management system (BMS) integration.		

2.3. Warranty Details

Make sure you know when the warranty expires as well as how to reach the manufacturer if you need to submit a warranty claim.

2.4. Commissioning Report

2.4.1. Overview

When a new dual fuel RTU or MUA is installed, the contractor follows a process to make sure everything is set up and working the way it should. This process involves two key parts:

- **Commissioning Checklist:** A step-by-step list the contractor uses to confirm the system is installed correctly and operating as intended.
- **Commissioning Report:** The completed record showing the results of those checks and tests. It confirms the system works properly, provides key details like model and serial numbers, and documents that the owner/operator has been shown how to use and maintain the system.

While only the **commissioning report** will be provided to you at the end of the project, we've included examples of both the checklist and the report so you can understand the process. If the contractor does not have a clear commissioning checklist, or if the report is unclear, this reference can help you know what types of checks they should be performing and documenting.

2.4.2. Commissioning Checklist Example

The following are physical checks that need to be completed to ensure the unit and all components are installed correctly.

Section	What To Check	Why It Matters
Install Details	• Ensure units are installed where planned, with clearances around all sides. • Confirm units are securely mounted and level. • Ensure isolation pads are installed to reduce vibration.	Ensures good airflow, safe service access, and prevents noise, vibration, and damage.
Refrigeration and Gas Piping	• All copper refrigerant lines should be insulated with closed foam insulation and covered with aluminum, PVC or other durable cladding to resist UV damage and bird/rodent interference. • Confirm gas piping is leak tested, supported, and properly labeled.	Copper piping is a common theft target, and exposed insulation can attract birds that peck or pull it apart for nesting material. Protective jacketing prevents physical damage, insulation degradation, and potential exposure of copper piping.
Sensor Placement	• Confirm supply air temperature (SAT) sensor is located downstream of both heating sections (heat pump coil and gas burner). • Verify outdoor air temperature (OAT) sensor is installed in a shaded, representative location.	Ensures accurate temperature readings for correct sequencing and control.
Condensate	• Inspect drain pans and lines: ensure pans are clean, lines have proper slope, and water drains freely. • Confirm any drain pan heaters (if installed) are connected and functional.	Prevents leaks, pooling, and freezing that can cause water damage.
Electrical and Controls	• Check all wiring is properly terminated, control signals are connected, and fuses/breakers are correctly sized.	Ensures reliable power and communication between system components.

The following are control and sequencing checks. These checks will ensure the unit is performing as intended.

Section	What To Check
Electrical Performance of Heat Pumps	• Set the heat pump compressor variable frequency drive (VFD) to 20%, 50%, 80%, and 100%. • Record electrical consumption (Amps) of each heat pump at each VFD speed.
Gas Backup Switchover	• Ensure the heat pump compressor is enabled, and the gas heater is disabled. • Adjust the gas enable SP such that the outdoor air temperature (OAT) is about to fall below that setpoint (SP). • Confirm that the heat pump compressor disables when the OAT drops below the gas enable SP and that the gas heater enables. • Adjust the gas heater enable SP to switch over to heat pump operation when the OAT rises above that SP. Record issues identified.
SAT Control (to be done in both heat pump and gas backup mode)	• Force the system into gas backup mode. • Manually set the supply air temperature (SAT) SP to a temporary value of 24°C. • Record time until SAT reaches SP (within deadband). • Record largest deviation from SP during 30 minutes. • Repeat with SPs of 21°C and 18°C. • Record issues identified. • Force the system into heat pump compressor mode and repeat the process.
OAT Lockout Control (If applicable)	• Set the OAT heating lockout SP such that the OAT is about to climb above that SP. • Record whether the heat pump's heating mode is disabled when the OAT increases above the OAT heating lockout SP. • Record whether the heat pump's heating mode is enabled when the OAT decreases below the deadband of the OAT heating lockout SP. • Set the OAT cooling lockout SP such that the OAT is about to fall below that SP. • Record whether the heat pump's cooling mode is disabled when the OAT decreases below the OAT cooling lockout SP. • Record whether the heat pump's cooling mode is enabled when the OAT increases above the deadband of the OAT cooling lockout SP. • Record issues identified.
Mixed Air Controls (RTU with CO2 sensing only)	• When CO2 levels are below the threshold, and return air temperature (RAT) < SAT in cooling mode, or RAT > SAT in heating mode, check that the return air (RA) damper is opening to appropriate position, and outdoor air (OA) damper is responding accordingly.
Free Cooling (RTU only)	• When OAT < RAT and there is cooling demand, check that the OA damper is fully open, and heat pump/direct-expansion (DX) coils are only supplementing the free cooling.
Demand-Controlled Ventilation Strategy (RTU only)	• If CO2 increases above SP, ensure that the minimum allowable position of the mixed air (MA) damper is increased to force higher ventilation. • If CO2 is below SP, ensure the minimum allowable MA damper position is decreased to recapture more heat and decrease emissions.
Freeze Stat Test	• Check that the freeze stat trips when condenser coil of the heat pump approaches freezing, typically around 7°C OAT.
Drainage and Condensate	• Observe condensate discharge during defrost or cooling mode. Ensure no leaks or pooling occur at the drain connection.

2.4.3. Commissioning Report Example

An example startup checklist for the Trane Precedent Packaged Rooftop Air Conditioners can be found here.

2.5. What to Watch Out For

Common field issues to be aware of include:

- The heat pump not operating as the first heating stage, or not operating as much as it could be, due to an overly high SAT SP or incorrect switchover settings between heat pump and gas heat.
- The SAT sensor installed too close to the gas burner, leading to short cycling.
- Condensate pooling caused by drain pans that are not properly sloped.

2.6. Training Session

As part of handoff, ask your contractor(s) to conduct a formal training session for facilities and maintenance staff. This has proven to be the best way to make sure everyone understands the system.

A sample agenda for a training session is laid out below. Consider recording the training for future reference or for new staff.

- System overview and walkthrough
    - Labeled diagrams should be presented here
- Controls and operation
    - Live demonstration of system operation, thermostat/building control module (BCM) controls, switchover logic (heat pump to gas), and typical display readings
- Maintenance schedule and requirements
    - Review of the maintenance checklist and how to complete routine inspections
- Documentation review, including manuals and warranty information
    - Make it clear where to find all the information
- Operational quirks and seasonal tips
- Training session deliverables
    - Copy of training materials: Slides, handouts, or digital copies of the presentation
    - Recorded session (if applicable): Useful for future reference and new staff orientation

2.7. Maintenance Requirements

The operation and maintenance information for your system is usually included in the equipment manual and should also be covered during your training session and project handoff. Be sure to review this information carefully and confirm that clear instructions are provided – either in the documents you receive, during training, or ideally in both places. This will help you feel confident in operating and maintaining your equipment. You'll want to make sure that both a maintenance schedule and a troubleshooting guide are provided.

2.7.1. Maintenance Schedule

The maintenance schedule should outline the types of checks and service tasks needed to keep your equipment running efficiently. This usually includes:

- **Filter cleaning/replacement** – how often this should be done (e.g., monthly or quarterly).
- **Part replacements** – when to replace key components like sensors.
- **Seasonal checks** – ensuring the system is ready before peak heating or cooling seasons.

A general example, as well as an example of what was provided for a specific project, can be found below.

2.7.1.1. General Maintenance Schedule

Frequency	Task	Who
Monthly	• Check filters, condensate drains, and outdoor coil for obstructions. • Check for refrigerant and water leaks.	On Site Staff
Seasonally*	• Check for blockages in drain pans and condensate piping. • Inspect condenser and evaporator coils, and clean/repair if necessary. • Inspect condenser fan, damper hinges, and all motors to ensure smooth movement and lubricated bearings. • Repair corrosion on exterior surfaces of unit. • Inspect controls and verify correct heat pump/gas sequencing. • Inspect air filters (clean or replace if needed). • Inspect and tighten electrical connections, belts, supports, and mechanical components. • With the unit running, check and record ambient temperature, compressor suction and discharge pressures, and superheat. • Clean burner area and verify functioning of gas heat system .	Licensed HVAC Contractor
Annually	• Full inspection of refrigerant circuit, gas burner, and electrical components. • Clean heat pump evaporator and condenser coils. • Clean and repaint corroded exterior surfaces.	Licensed HVAC Contractor

** source: https://www.trane.com/content/dam/Trane/Commercial/lar/es/product-systems/comercial/Rooftops/Precedent/iom/Precedent%203%20a%2010%20TR%20Gas-El%C3%A9ctrico%20IOM%20(Ingl%C3%A9s).pdf*

2.7.2. Troubleshooting Guide

The troubleshooting guide should outline common issues you may encounter and provide straightforward steps to address them. A general example is included below. If the initial on-site checks do not resolve the problem – or if any steps fall outside your comfort level – contact the installer (if the unit is still under warranty) or the service contractor for further support.

Warning Sign / Issue	Initial On Site Checks	Where to Find More Information
Unit won't turn on	• Check main disconnect and circuit breakers. • Confirm control power to thermostat or building automation system (BAS) is on. • Verify emergency stop (if present) is not engaged. • Check supply fan proving switch, clogged filter switch, and condensate overflow switch.	Operation manual – electrical section
Heat pump not operating / gas heat only	• Check that the controller mode is set to "auto" or "heat pump first." • Confirm outdoor temperature above switchover point. • Verify heat pump breakers are on.	Operation manual – heating sequence section
Gas heat not engaging	• Confirm gas supply is open. • Ensure unit is set to heat. • Confirm outdoor air temperature (OAT) lockout and switchover setpoints (SPs).	Operation manual – heating section
Supply air feels too cold/ hot	• Check zone temperature and SP. • Check filters and coils for blockage.	Operation manual – control settings section
Airflow feels weak	• Clean or replace air filters. • Check for dirty evaporator and condenser coils. • Ensure air intake and exhaust paths are not obstructed. • Check return and clean return air grills.	Operation manual – fan section
Water dripping or pooling around unit	• Check condensate drain for blockage or improper slope. • Ensure drain pan heater (if installed) is operational.	Operation manual – condensate drainage section
Unusual noise or vibration	• Check panels, fan guards, and isolation pads. • Ensure no tools or debris on unit. • Check that belts are not worn out.	Operation manual – maintenance section
Error code or alarm displayed	• Record the exact error code. • Refer to manual for code meaning.	Operation manual – troubleshooting section
System short cycling	• Verify thermostat or BAS control settings. • Check supply air temperature (SAT) sensor placement and system SPs.	Operation manual – control setup section
Excessive vibration transmitted indoors	• Check that isolation pads are properly installed and not compressed. • Inspect compressor mounting.	Operation manual – installation section
Gas smell or suspected leak	• Shut off unit immediately. • Ventilate area and contact service provider or gas utility. • Do not attempt to restart.	Safety procedures

sources:

- *https://www.trane.com/content/dam/Trane/Commercial/lar/es/product-systems/comercial/Rooftops/Precedent/iom/Precedent%203%20a%2010%20TR%20Gas-El%C3%A9ctrico%20IOM%20(Ingl%C3%A9s).pdf*
- *https://www.partstown.com/cm/resource-center/guides/gd2/rooftop-unit-troubleshooting-tips?srsltid=AfmBOoqCxpogltgUvGaKa-7Jl7AasLfKGkrmO-J5OsDJpl8AEJSambp1*

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