Editor's note: This is the second in a series of articles on make-up air (MUA) systems that explores the different types of MUA applications to help readers develop a basic understanding of these systems. MUA systems are used to bring in fresh outside air and maintain desired conditions at an acceptable temperature and humidity. This article will focus on typical unitary MUA systems, which combine heating, cooling and fan sections in one or a few assemblies.

Unitary MUA systems are usually located on rooftops and take on the appearance of standard rooftop package units. The purpose of a unitary MUA system, however, is quite different from standard comfort cooling/heating applications. It is that very difference that makes it even more important for the service technician to have a full understanding of this design application to ensure the system is set up and maintained to meet its original design intent.

The first article in this series (Feb. 2018, RSES Journal) discussed the importance of providing the proper amount of air exchange to a structure and delivering this make-up air at the correct temperature and humidity levels. It also focused on the need to maintain proper internal air pressures to avoid undesirable infiltration. To accomplish these end goals with a unitary MUA unit there first needs to be a focus on the unit's main components, which include:

→ **System compressors:** There are usually at least two system compressors in a unitary MUA unit, and depending on the nominal capacity, there may be several or more. The first stages of compressor(s) are equipped with digital unloading. This, along with added mechanical components such as hot gas bypass valves, are required to meet the challenges of dehumidification control and reheat control. These issues will be explained later in this article. The remaining compressors are used for proper evaporator coil temperature and additional dehumidification capacity as required.

→ **Evaporator coil:** The evaporator coil on a unitary MUA unit differs from a conventional comfort cooling direct expansion (DX) heat exchanger in that its design consists of more rows and passes than a standard coil. As a result, its design temperature differential (TD) is much higher, and with the proper amount of airflow through the coil the leaving air will be at the correct temperature and sufficiently dehumidified.

→ **Hot gas reheat coil:** This coil is mounted downstream of the evaporator coil and receives hot discharge gas directly from the compressor through a series of diverting valves. When the discharge air temperature of the unit decreases below set point, the unit’s controller will signal the diverting valves to bypass the condenser circuits of the first stage compressor and divert the discharge vapor to the hot gas reheat coil. The result is a rise in discharge air temperature to set point.

→ **Heat recovery wheel assembly:** This assembly consists of a media-filled wheel rotating in two air streams. The building exhaust air and the building’s outdoor air both pass through this wheel. The desiccant material which makes up the media serves as an absorbent. Some of the humidity in
the incoming outdoor air in the summertime is absorbed into the media. At the same time, the exhaust air, which for all practical purposes is conditioned air, serves as the heat exchange medium in that it helps to absorb some of that incoming humidity while dropping the sensible temperature of the warmer incoming outdoor non-conditioned air.

Conversely, in winter mode, the colder incoming outdoor air is preheated by the same principals of heat exchange. When conditions exist, the relative humidity levels are also affected. These principals make the heat recovery wheel, also known as the enthalpy wheel, a critical component in these types of systems. When the system is operating correctly and controlled according to its design intent, the results yield substantial energy recovery savings and the introduction of make-up air to the structure at the proper content.

→ The heating section: The heating section of these units can consist of gas-fired burners, usually at least two stages of operation. The turn down ratio of these burners allow for fully modulating heating capacities down to usually one-third capacity or more. These units can also be affixed with hot water or even steam coils as a heat source and are equipped with full modulation valves and controls.

→ Air moving components: Most systems employ a main supply blower that can be variable speed if the system requires. Also on the system is a power exhaust blower that serves the structure’s exhaust requirements in rest rooms, common areas and mechanical rooms, depending on the specific building requirements.

→ Dampers: The unit is affixed with several sets of dampers. It can be equipped with outdoor air dampers at the intake hood that modulate to a full 100% open position anytime the main supply fan is running. A set of opposed blade dampers are positioned between the outdoor air stream and the exhaust ducting, which is also positioned so that only outdoor air is introduced and exhaust air is diverted to the power exhaust box.

Some buildings can use a portion of the exhaust to dilute with the outdoor air. That is the purpose of opposed blade dampers. It should be noted that mixing a small percentage of building exhaust with outdoor air, or, in other words, with some exhaust recirculating by means of dilution with outdoor fresh air, must be done with caution. The building's exhaust contains harmful volatile organic compounds (VOCs), so strict minimum guidelines must be adhered to.

Unitary MUA system controls
The unitary MUA system’s control package will differ from application to application, depending on how the unit was ordered. But there are some main controls and sensors that are standard. Typical modes of operation include:

→ Main control board: This is the heart of the control system. It is linked via communication cable to the rest of the control boards on the unit. The main board receives information from all the units’ sensors and determines what mode of operation the unit will run in.
→**Supply fan/exhaust fan only:** In this mode no mechanical equipment other than blowers is operating. This mode is active when the set point has been reached, when outdoor air temperature and humidity conditions are favorable, and during brief periods immediately after startup or when the control system is coming out of night setback mode.

→**Dehumidification priority:** In this mode the first stage of the compressor operates to provide dehumidification control of the outdoor air. Once the outdoor air passes through the energy recovery wheel, the evaporator coil is activated to dehumidify the air further, with the controller adding additional stages of compressors as-needed, based on the supply air sensor's input.

→**Cooling mode:** In this mode the system supply air temperature sensor is attempting to maintain the discharge air temperature, and during high-temperature outdoor air conditions the controller will continue indexing compressors on to meet this requirement. The dehumidification components will continue to function without the use of hot gas reheat.

→**Heating mode:** In this mode compressors are not allowed to operate, and the supply air is held at set point by indexing stages of heat on as needed.

**General system control theory**

The control of unitary MUA systems is critical. One must understand the primary purpose of this unit is to provide make-up air, which is supply air delivered at or around 70°F with 50% relative humidity. This is also referred to as neutral air. Unitary MUA systems are neither primary cooling nor heating units. Once that is understood, the control of the system becomes clearer. The system uses outdoor air as the main medium to be conditioned prior to delivery to the structure. The heat recovery/enthalpy wheel will provide a substantial sensible heat gain in colder outdoor air temperatures coming in, and a substantial drop in dry bulb and relative humidity in warmer incoming air. However, the air leaving the wheel usually needs to be conditioned further to reach set point.

This is why the outdoor air conditions are the best primary method to be used for dictating to the main control board which mode the unit should run in. When choosing a control method, outdoor air with dehumidification priority is best. With this method the unit first looks at outdoor air conditions and then selects the main mode of operation. When programming the unit's sub menus under this category, many different choices need to be selected. It is absolutely imperative the programmer read and fully understand all accompanying control literature prior to selection.

The end result when properly programmed is a fully functional make-up air system delivering neutral air to the facility year round despite outdoor air conditions.

**Other key control methods**

Aside from the standard control methods, there are many more sophisticated methods of control that can be tailored to meet the specific building's specifications. The most important thing to remember is the end goal is not for the MUA unit to function as a primary heating/cooling unit, but to deliver neutral air to the structure. Other key control methods found on unitary MUA systems include:

→**Sensors:** The unit's main control board receives input from an outdoor humidity/temperature sensor, a supply air sensor, and in some cases an exhaust or return air sensor or a space sensor.
These sensors, depending on the control method selected, report to the main control board, which through a method of calculations, decides what outputs to energize.

→ Modulating hot gas reheat control board: This board is signaled by the main control board and, in turn, signals drive outputs to the hot gas reheat diverting valves. The valves in the first position in the discharge line and in the first position in a branch pipe of a bypass tee, drive in reverse sequence to one another. What this means is one valve is driven open while the other is driven closed in unison. The result is a modulation of hot gas either to the condenser coil of the first stage compressor or to the reheat coil. This modulation is dictated by the discharge air temperature versus the set point.

→ Modulating, heating control board: This board can control modulating outputs to gas-fired burners or a unit mounted hot water coil control valve. In some applications a unit-mounted steam coil’s control valve may be controlled. In either case the board receives signals from the main control board and in turn sends modulating output drive signals to the heating section components. The supply air, and sometimes the space sensor, communicates to the board, which in turn decides modulation capacity. In gas heating applications, the first stage burner section starts in high fire and then modulates down after a time delay via a dc modulating gas valve in the gas train.

The control algorithm here is a coil set point that is mapped into the main control board at the time of programming. The typical coil set point is around 40-45°F. This means the target boiling point of the evaporator coil is set to maintain 40°F.

The suction pressure transducer measures operating suction pressure of the first stage compressor, converts that pressure into saturation temp for the refrigerant in the system, and sends the information to the unloader’s control module via a variable 0-5V dc signal. The unloader module in turn loads and unloads the compressor accordingly. It is important to maintain the proper refrigerant charge in the system along with other operational specifications to obtain correct capacity control results.

→ Discharge pressure control: The system uses condenser fan cycling encapsulated pressure stats to maintain an inflated condensing temperature in order to supply the proper temperature of hot gas reheat. The pressure stats cycle condenser fans at a substantially higher than normal cut in pressure to accomplish this.

Summary
The main goal of this article is to familiarize the reader with one specific type among many types of MUA applications, and also express the importance of understanding the unique differences in these units versus standard comfort cooling applications.

It is important to note that many of the features, control options, and auxiliary components found on these systems were not discussed due to space limitations. Moreover, it is critical that installing/servicing personnel and end users have a clear and definitive understanding of the primary purposes of MUA systems. That is to provide neutral make-up air to the structure in such a way that it serves the structure’s interior atmosphere to maintain safe levels of VOCs and proper interior pressures to prevent potential health hazards to occupants.

A properly designed, applied and maintained make-up air system will ensure not only occupant health and safety, but also serve to meet all commercial building air exchange requirements as outlined in numerous, local, state and federal guidelines and governing institutions.

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In the case of control valves for water or steam coils, a modulating dc signal is produced and sent to the valves.

→ First stage compressor capacity control: The first stage compressor is applied with direct digital unloading. The loading and unloading sequencing is accomplished via a suction pressure transducer mounted on the suction line of the first stage compressor. This transducer is wired to an expansion module which is connected via communication cable to the main board. A dc output signal to the digital unloader comes from its control module.

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Author’s note: The next article in this series will explore other types of typical MUA systems found in commercial-industrial structures.

Rich Perrotta has 40 years of experience in the commercial/industrial sector of HVACR. He has been an instructor in the HVACR adult education program for Bucks County Institute of Technology in Fairless Hills, PA, for over 25 years. One of his main focuses is to educate people entering the HVACR trade through teaching, coaching and mentoring.